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Cover: Ploughing through the bar. This Coast Guard motor lifeboat batters its way into the Pacific Ocean via the treacherous Columbia River bar. See article on page 15. U.S. Coast Guard Photo.

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Mariners Weather Log

FORECASTING HURRICANE WAVES

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Although prehistoric man knew that the wind blowing over the surface of the sea produced waves, it is only in recent years that we have acquired sufficient understanding of that process to make reliable, useful wave prediction a practical possibility. Prior to World War II, those people concerned with surface-water waves fell into two distinct groups: the hydrodynamicists who concerned themselves with the simplified, idealized problems for which their precomputer mathematics were adequate; and the mariners who had to deal with the vastly more complex real world on a day-to-day basis. There was not much communication between the two camps. The hydrodynamicists despaired of making sense out of the chaos of a real sea, and the mariners failed to find anything useful in the idealized models. This situation changed in World War II, when H.U. Sverdrup and W.H. Munk were called upon to develop a wave-forecasting scheme which would have some utility in planning military operations. Drawing on the best available knowledge at the time from both camps, they developed a technique (made public after the war in H.O. Publication No. 601, March 1947)

Figure 1.--This merchant vessel was caught in hurricane Carol in 1954. The photograph was taken by a U.S. Navy hurricane-hunter aircraft based at Jacksonville, Fla. U.S. Navy Photograph.

which, though in many respects primitive and in some respects simply wrong, undoubtedly led to the saving of thousands of lives in the massive amphibious operations conducted after 1943.

Great progress has been made since that first step forward, largely as a result of the recognition in the late 1940s and the early 1950's that the surface of the sea can only be usefully described statistically, and that the fundamental statistic is the two-dimensional surface wave spectrum. Given this property of the sea state, any other statistical property can be calculated; for example, such quantities as average wave height, period, and propagation direction; average momentum and energy in the wave field; mean squared, wave-induced water velocity; maximum probable wave height; and so on. The development of the two-dimensional wave spectrum in space and time is governed by a simple (at least in principle) mathematical equation. All modern wave prediction schemes are based upon obtaining solutions to this equation, the methods differing only in the construction of the elements of the equation and the methods employed to solve it.

The value of a reliable wave prediction scheme used a a forecasting tool is obvious (e. g., in planning military operations, ship routing, and so on). The U.S. Navy has a massive computerized wave-prediction scheme based on these principles in routine operation (Lazanoff and Stevenson, 1975), producing wave forecasts to 72 hr for the Northern Hemisphere. But it is potentially of even greater value used in the "hindcasting mode." As the fundamental description of sea state, the two-dimensional wave spectrum now plays a central role in the design of ships and marine structures, providing all the information needed by the engineer to compute the wave-induced stresses and excitations to which his designs will be subjected. Unfortunately, measurement of the two-dimensional spectrum is difficult, particularly under the severe conditions which primarily concern the engineer, so that few field observations exist. However, a great deal of data is available on the winds associated with storms; and a reliable wave-prediction scheme, driven by the wind fields of historical storms, can "hindcast" the corresponding wave spectra, providing the engineer with site-specific design criteria which would otherwise be unobtainable.

The development of the wave spectrum under hurricane winds (fig. 1) has been a problem of central interest at the Sea-Air Interaction Laboratory (SAIL) of NOAA's Atlantic Oceanographic and Meteorological Laboratories in Miami, Fla, for a number of years. In the course of this work several wave-prediction schemes (more simply, wave models) have been implemented on a UNIVAC 1108 computer. Used with the wind fields of theoretical model storms or reconstructed wind fields of historical storms, these wave models predict the development of the wave spectrum over the area affected by the storm as time advances. For historical storms, wave measurements made by aircraft penetrations or by moored data buoys are employed to test the performance of the wave models, while theoretical storms are used to study the response of the models to variations in the mix of theory and empiricism defining the governing equation. In the process, a great deal has been learned about the sea states generated in hurricanes. One of the most interesting discoveries is that the wave field development under a hurricane is frequently simple enough to be calculated to useful accuracy by hand.

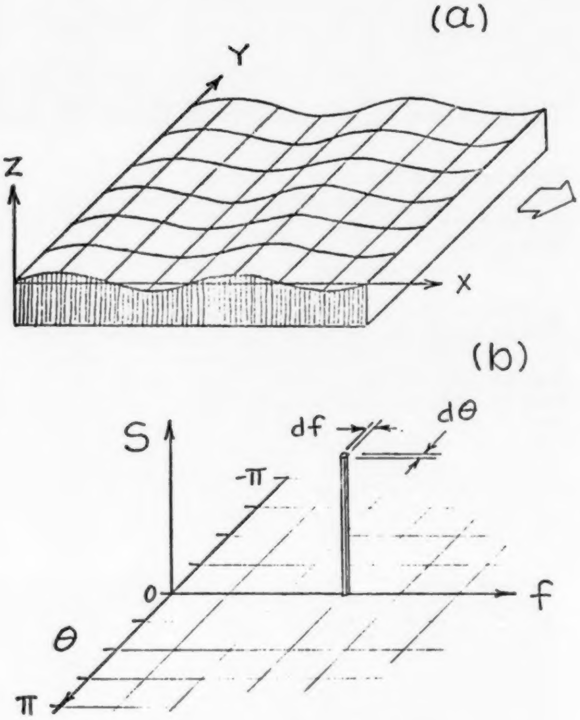

Figure 2.--Single-component sea and corresponding spectrum. The sinusoidal wave of panel (a) is propagating to the right along the x-direction. Panel (b) shows the corresponding directional spectrum $S(f, \theta)$, where f is the wave frequency and θ its propagation direction. θ is measured in radians on the range $-\pi$ to $+\pi$ (-180° to +180°) relative to the direction of x. The value of S (the height of the spike is proportional to the square of wave amplitude.

THE SPECTRUM

In order to understand how modern wave-prediction schemes work, it is necessary to understand the concept of the two-dimensional wave spectrum and its relationship to sea state.

The concept arises from three fundamental facts, the first strictly mathematical and the others related to the physics of fluid motion:

1. A wrinkled surface which is evolving with time, such as the air-sea interface, can be mathematically decomposed into the sum of many sinusoidal waves with different amplitudes, wavelengths, propagation directions, and speeds (the procedure is called Fourier analysis). Figure 2(a) shows one such sinusoidal wave component.

2. In the case of the air-sea interface, each component propagates independently, interacting only very weakly with the others, at a phase speed (speed at which the wave appears to move) determined by its wavelength

to think of the spike as occupying a small, rectangular area in the (f, θ) plane with sides df and dθ; the height of the spike, S(f, θ), is such that its volume, df dθ S(f, θ), is equal to half of the square of the corresponding wave amplitude.

This example, though consistent with the physics of the water motion, is certainly not typical of a real sea. A more complicated example, a two-component sea composed of waves of equal amplitude running at +45° and -45° with respect to the x-direction, is shown in figure 4. The result, a regular pattern of humps and hollows which propagates without change of shape along the x-direction, is again not very realistic.

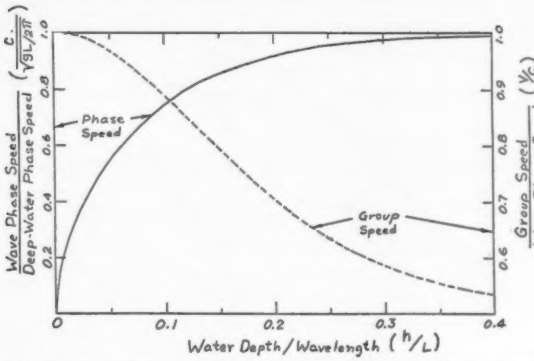

Figure 3.--Dispersion characteristics of sinusoidal surface gravity waves (C = phase speed, V = group speed, L = wave length, h = water depth, and acceleration of gravity g = 9.8 m/s^2 in metric units). As h/L becomes larger than 0.5 (deep water or short wavelength), the group speed approaches half the wave-phase speed, which becomes approximately $\sqrt{g\ L/2\pi}$ (the phase speed of a wave where gravity is the restoring force and the maximum propagation speed for a surface wave of length L).

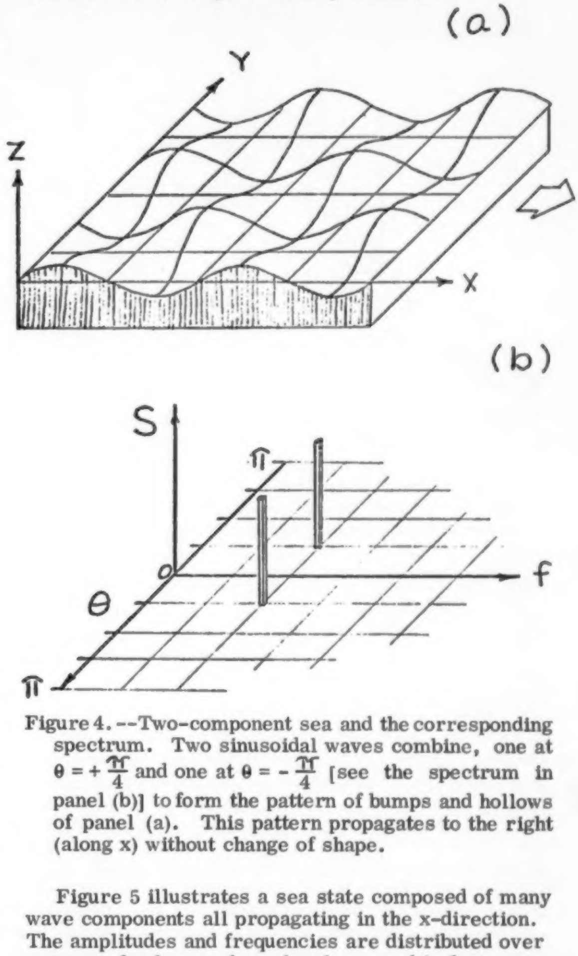

Figure 4.--Two-component sea and the corresponding spectrum. Two sinusoidal waves combine, one at $\theta = +\frac{\pi}{4}$ and one at $\theta = -\frac{\pi}{4}$ [see the spectrum in panel (b)] to form the pattern of bumps and hollows of panel (a). This pattern propagates to the right (along x) without change of shape.

and the average water depth. This relationship (called the dispersion relation) is plotted in figure 3.

3. Each sinusoidal wave component posseses energy due to its contribution to surface distortion and to wave-induced water velocities. The amount of energy residing in each component is proportional to the square of its amplitude and propagates in the same direction as the sinusoidal wave at the so-called group velocity (velocity of the energy). In deep water the group velocity is one-half of the wave phase velocity (see fig. 3).

As a result of these facts, the seemingly chaotic surface of the real sea can be completely characterized by a statement of the distribution of energy among the various sinusoidal components making up the wave field. The two-dimensional wave spectrum is just such a statement. The spectrum is said to be two dimensional because, thanks to the dispersion relation, only two variables are necessary to identify each wave component. An especially convenient pair is propagation direction (for which we use the symbol θ) and cyclic frequency (symbolized by f). This last is the frequency at which an observer would see the surface oscillating up and down as a sinusoidal wave propagates past a fixed point and equals the wave phase speed divided by its wavelength. The frequency, in turn, fixes the corresponding wavelength, phase speed, and group speed through the dispersion relation. With this choice of wave variables, the two-dimensional spectrum is assigned the more descriptive name directional spectrum (which we abbreviate to "S(f, θ)").

Figure 2(a) illustrates schematically the simplest possible sea state, a single wave component propagating, in this case along the x-direction. The corresponding directional spectrum (shown in panel b) is 0 everywhere except for a single spike at the point in the (f, θ) plane corresponding to the frequency and propagation direction of the existing wave. It is conventional

Figure 5 illustrates a sea state composed of many wave components all propagating in the x-direction. The amplitudes and frequencies are distributed over a range of values and so closely spaced in frequency that the distribution is virtually continuous. The resulting profile along x looks real, and individual features appear to propagate and change shape in a realistic fashion because of the different phase speeds of the different wave components. However, profiles along y are straight lines, which certainly are not realistic. What is needed is a spectrum distributed both in frequency and direction, so that the resulting sea will combine the properties corresponding to the slab-like unidirectional spectrum of figure 5 with the

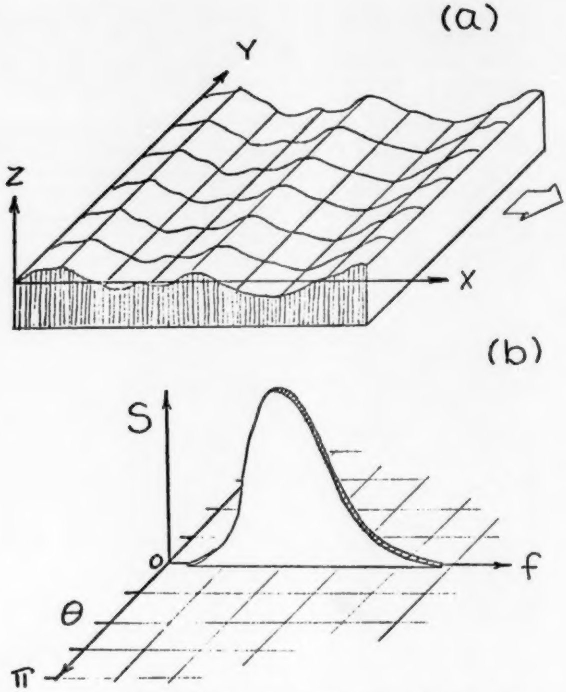

Figure 5.--Unidirectional multicomponent sea and corresponding spectrum. The pattern of infinitely long-crested waves propagates to the right (along x) and changes shape as it moves (see panel a). The corresponding spectrum exhibits a continuous range of frequencies, but only one direction.

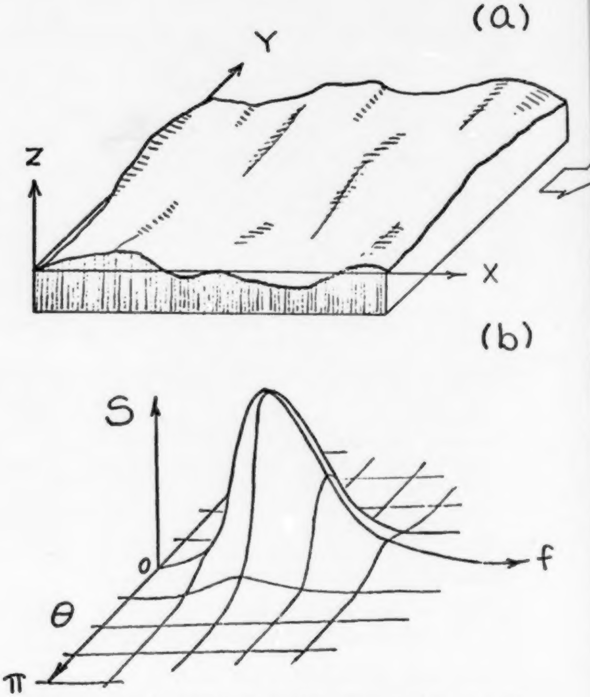

Figure 6.--A directional, multicomponent sea and corresponding spectrum. A pattern of waves with limited crest lengths propagates to the right (along x), changing shape as it moves (see panel a). The spectrum (panel b) has a continuous range of frequencies and directions.

short-crestedness of the two-component model of figure 4. The result in figure 6 does indeed yield a reasonable facsimile of a real sea.

The sample spectrum sketched in figure 6(b) is typical of a directional spectrum generated by a wind blowing along x ($\theta = 0$), judging by the limited amount of available experimental data (Mitsuyasu et al, 1975). Much more complicated shapes are possible. For example, if the local sea consisted of a wind-generated part and a swell component caused by a distant storm, the spectrum would have two humps--one resembling 6(b) and a second sharper one centered on the frequency and propagation direction of the incoming swell. Other influences may also distort the spectral shape, such as asymmetrical fetch, rapidly changing winds, bottom influence, and so forth. A complete wave-prediction scheme must take all of these effects into account.

In any case, once $S(f,\theta)$ is known (that is, we have a quantitative statement of the value of S for every wave frequency and direction), then all other statistical properties of the sea state may be calculated. For example, the average energy per unit horizontal area (E_t) residing in the wave field is computed by multiplying $S(f,\theta)$ by the small area ($df\, d\theta$) assigned to each wave component and by the density of water (ρ) and the acceleration of gravity (g), then summing (integrating) over all possible components (all possible areas $df\, d\theta$). This operation is written:

$$E_t = \int_0^\infty df \int_{-\pi}^{\pi} d\theta \; \rho \; g \; S(f,\theta)$$

Another, perhaps more familiar statistic is significant wave height ($H_{1/3}$), which is proportional to the square root of the average energy density:

$$H_{1/3} = 4 \left(\frac{1}{\rho g} E_t\right)^{1/2}$$

$H_{1/3}$ has been shown to be the same as the average trough-to-crest height of the third highest waves occurring in the sea defined by $S(f,\theta)$. Experience indicates that this is very near the value which a trained observer would estimate visually as "wave height."

Other average properties of the wave field can be computed in a similar way; i.e., multiply $S(f,\theta)$ by an appropriate factor (which may itself depend on f and/or θ), then by $df\, d\theta$, then sum over all possible wave component directions and frequencies. Some properties, such as maximum probable wave height or maximum probable water velocity, are more difficult to calculate and require additional statements about what "maximum probable" means. Results for trough-to-crest wave height have been calculated by Longuet-Higgins (1952) and are tabulated by Pierson et al. (1967) (H.O. Publication No. 603) in terms of the highest wave which one will observe in any group of N waves passing

Table 1.--Maximum wave heights in a group of N waves

N	5 % lower than	Most frequent	Average	5 % higher than
20	.99 $H_{1/3}$	1.22 $H_{1/3}$	1.32 $H_{1/3}$	1.73 $H_{1/3}$
50	1.19 $H_{1/3}$	1.40 $H_{1/3}$	1.50 $H_{1/3}$	1.86 $H_{1/3}$
100	1.33 $H_{1/3}$	1.52 $H_{1/3}$	1.61 $H_{1/3}$	1.94 $H_{1/3}$
200	1.45 $H_{1/3}$	1.63 $H_{1/3}$	1.72 $H_{1/3}$	2.03 $H_{1/3}$
500	1.60 $H_{1/3}$	1.76 $H_{1/3}$	1.84 $H_{1/3}$	2.14 $H_{1/3}$
1000	1.70 $H_{1/3}$	1.86 $H_{1/3}$	1.93 $H_{1/3}$	2.22 $H_{1/3}$

(after Pierson et al., 1967)

by. For example (table 1), if one observes 20 waves passing by, the probability that the highest wave seen will be lower than .99 $H_{1/3}$ is 5 percent. The probability that the highest wave will be higher that 1.73 $H_{1/3}$ is 5 percent. Most of the time a maximum height near 1.22 $H_{1/3}$ will be seen, but the average maximum height will be 1.32 $H_{1/3}$.

MEASURING THE SPECTRUM

The spectrum is a statistical quantity (like the average weight of coconuts) and can never be measured exactly. To get it exactly right, we would have to observe a given sea everywhere and for all time (weigh every coconut in the universe) which is impossible. The best we can do is to assemble a few short-time histories of sea-surface elevation at several points, or different characteristics of the wave field at a single point, and from these estimate the spectrum (do the best we can with a few coconuts). The result inevitably will contain some error, but this can be controlled by varying the size of the data set, and the significance of the probable error can be estimated for a given data set.

The simplest wave measurements are made with a single wave gage (for example, a resistance wire or capacitance wave staff which penetrates the surface and measures its displacement or, in deep water, a buoy mounting a vertical accelerometer which measures the vertical motion of the surface). A single wave gage yields a time history of surface displacement at a single location (Kinsman, 1965). To such an instrument, a sinusoidal wave component of a given frequency looks the same regardless of its propagation direction. By Fourier analyzing the time series, an estimate of the energy resident in all wave components with a given frequency, independent of direction, can be calculated. The results are expressed in terms of the frequency spectrum E(f), which can be derived, like the other statistics of the wave field, from the directional spectrum whenever it is known; we multiply $S(f,\theta)$ by $d\theta$ and sum (integrate) over all possible directions:

$$E(f) = \int_{-\pi}^{\pi} d\theta \; S(f,\theta)$$

An example of a frequency spectrum measured in a hurricane is shown in figure 7. This was obtained by one of NOAA's moored data buoys in the Gulf of Mexico and represents the kind of field data against which our hurricane wave models have been tested.

One way of getting directional information is to use

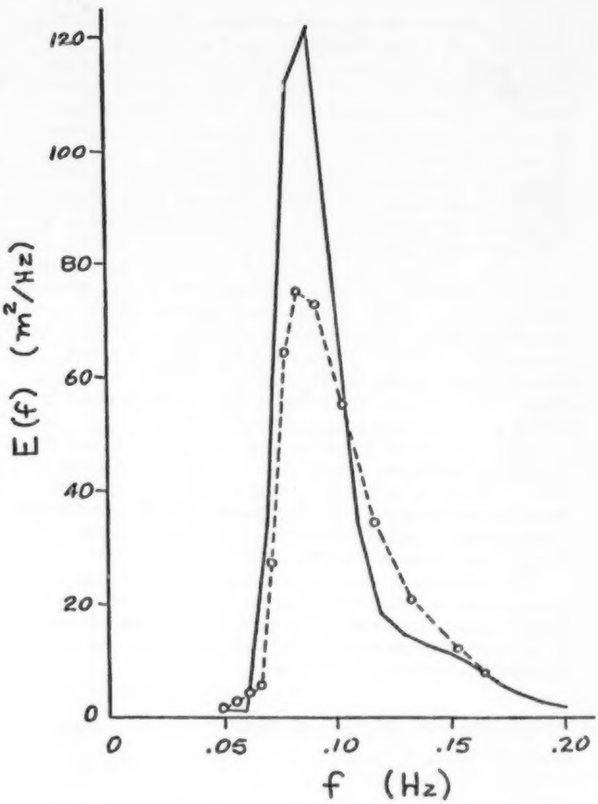

Figure 7.--Comparison of the highest sea-state wave-frequency spectrum observed by the NOAA data buoy during hurricane Eloise (—) with the spectrum predicted by the full-scale spectral wave model (--). Although the model underestimates the peak, the comparison is considered satisfactory (observed $H_{1/3}$ = 9 m, predicted $H_{1/3}$ = 8.1 m). Significant wave heights are determined by the total area under these curves. In this example the overestimation of the model spectrum for frequencies above the peak partially offsets the underestimation near the peak resulting in good agreement for $H_{1/3}$.

an array of wave gages to obtain time series of surface displacement at several different space points (Barber, 1963). Since the crest of a sinusoidal wave component passing through the array arrives at each gage at a different time, it is possible to estimate the direction of propagation by comparing the time series (this is a gross oversimplification of the procedure called cross spectral analysis, but it points out the principle). A wave gage array has been used from the research vessel FLIP (Regier and Davis, 1977), but the technique is generally applied only in shallow water because the position of the gages must remain fixed relative to each other.

The most commonly used instrument for measuring deep-water directional spectra is the pitch/roll buoy (Longuet-Higgins et al., 1963). A gyro-stabilized platform supporting a vertical accelerometer is mounted

on a disc or toroid-shaped buoy designed to follow the slope as well as the vertical motion of the water surface. Four time series are recorded: vertical acceleration, pitch, roll, and buoy heading relative to north. Comparing these signals permits an estimate of the directional distribution of wave energy at each frequency, although with so little information, directional resolution is not very good. Because the buoy must be launched and recovered from a ship and has a tendency to capsize in rough seas, no hurricane data have been obtained using this instrument.

In fact, much of the hurricane wave data used in the research at SAIL has been obtained from storm penetrations by aircraft. The aircraft carries a laser altimeter (a modified surveying instrument) which measures the vertical distance from the aircraft to the water surface along the aircraft track. The resulting time series of surface elevation can be interpreted in terms of a wave frequency spectrum (Ross et al., 1970).

Other remote-sensing techniques are now becoming available, including satellite radars and radio altimeters. These will eventually make important contributions to our knowledge of storm seas and our ability to predict them, though it is still too early for their impact to have been more than minimal.

We neglected to mention some frequently used in situ measurement techniques, such as multicomponent current meters, arrays of water pressure gages, and others, but the techniques outlined are sufficient to illustrate the relevant principles.

THE RADIATION BALANCE

Having established that the two-dimensional wave spectrum is the complete definition of sea state, we now need some basis on which to predict its development in space and time. This is provided by the so-called radiation balance equation, a mathematical statement about the balance of processes which insert, remove, and redistribute wave energy, component by component, across the spectrum. The structure of this equation can be described schematically as follows:

$$\boxed{\begin{array}{c}\text{Local rate of}\\ \text{change with time}\\ \text{of component}\\ \text{wave energy}\end{array}} = \boxed{\begin{array}{c}\text{Effect of energy}\\ \text{transport at the}\\ \text{group velocity}\end{array}} + \boxed{\begin{array}{c}\text{Effect of wave}\\ \text{refraction by}\\ \text{current and}\\ \text{depth changes}\end{array}} + \boxed{\begin{array}{c}\text{All sources and}\\ \text{sinks of wave}\\ \text{component energy}\end{array}}$$

The left-hand side is what an observer would see if he stood at some fixed point and watched the spectrum develop. Once the spectrum and its rate of change are known at a given location and time, we can mathematically predict the growth or decay of each wave component. The rate of change is determined by the processes indicated in the boxes on the right-hand side. The first of these is the effect of wave-component energy propagating from place to place at the corresponding group velocity; for example, if an observer found himself down-wave of a region where the spectrum was greater, he would find the spectrum at his location increasing with time as the higher energy levels propagated through his position. The second term represents refractive effects which can cause energy to pile up, spread out, or be transferred from one wave component to another (turned). These two processes are completely understood from first principles. The final term on the right is not well understood, and most ongoing wave research is currently directed at getting a better empirical description and theoretical understanding of the sources and sinks of wave spectral energy. The most important of these are (1) the input from the wind (source), (2) the dissipation by whitecapping (sink), and (3) a process called nonlinear transfer (source or sink depending on the shape of the rest of the spectrum). Of these effects, only (3) is known from first principles; it arises because the individual wave components are not totally decoupled from each other, and this weak interaction is capable of redistributing wave energy across the spectrum. In the present generation of wave-prediction schemes, (1) and (2) must be approximated by mathematical rules-of-thumb guided by whatever theory is available and substance determined empirically by observations. Nonlinear transfer is also generally dealt with similarly because, although it is possible to accurately compute the effect from theory, the effort required is too great to be done as an integral part of a practical wave-prediction scheme. It is the difference in how these effects are approximated that constitutes the primary difference between the various computer-based, wave-prediction schemes presently under development or in use.

Once the radiation balance is written down, it is solved using a digital computer on a grid of discrete points representing geographical locations on Earth. The effects of fetch are incorporated by applying boundary conditions at those grid points which lie on coastlines; usually, these conditions specify that there is no energy in wave components with propagation directions in the offshore semicircle. On grid boundaries which lie in open water the energy in wave components propagating into the grid must be specified. In our hurricane applications, for example, we generally specify that no wave energy is coming in from outside the grid; all the wave energy present must then be generated by the hurricane imbedded in the grid.

In practice, the program is started at some chosen time at which the spectrum everywhere on the grid is specified by initial conditions. For lack of better information, we generally set the spectrum to 0 everywhere at start time. Then, using a known or forecast time history of the wind field at each grid point, the computer program marches forward in time, recomputing the spectrum at each grid point at each time step. After advancing 6 to 12 hr (a few min of computer time), the wave field has "spun up," and realistic spectral values develop.

APPLICATION TO HURRICANES

To drive a hurricane wave model (i.e., specify final term on the right in the radiation balance equation), the wind field has to be known at every grid point over the history of the storm. Such dense measurements are, of course, never available; and in our hurricane studies the best wind observations have been provided by the same aircraft storm penetrations which provided much of the wave data. NOAA research aircraft use inertial navigation systems to measure groundspeed and track; comparing this with airspeed and heading allows the windspeed and direction to be computed. From observations of this sort, as well as data from ships, oil-well platforms, and moored-data buoys, a computer

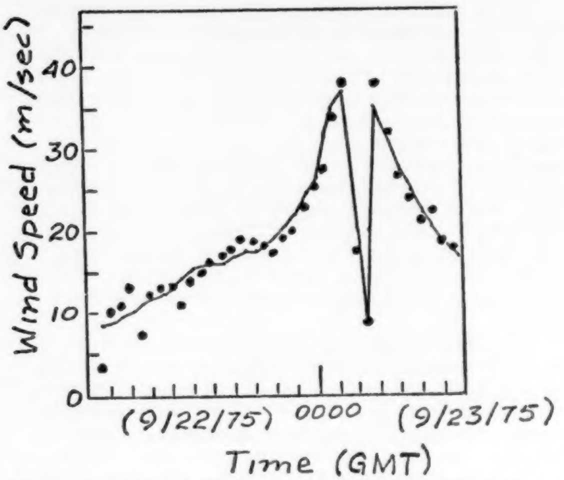

Figure 8.--Comparison of windspeed as measured by a NOAA data buoy during hurricane Eloise (•) and as computed from the SAIL hurricane wind model (—) (Ross and Cardone, 1978). The windspeeds are equivalent to 15-min averages at 10-m height above the water surface.

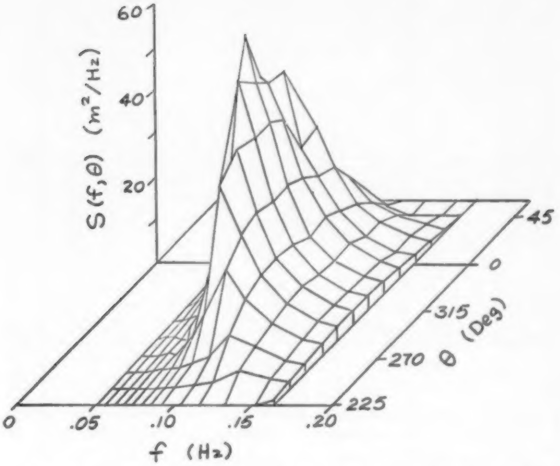

Figure 9.--The directional spectrum predicted by the spectral wave model for the NOAA data buoy location at highest sea state. The frequency spectrum of figure 7 was computed from this directional spectrum by integrating over direction (summing all the spectral density in each frequency band). The tail of the spectrum is cut off at about .16 Hz because the computer model does not explicitly treat higher frequency bands.

Figure 10.--This aerial photograph illustrates the sea conditions as they could be expected to appear with 75-kn winds. U.S. Navy Photograph.

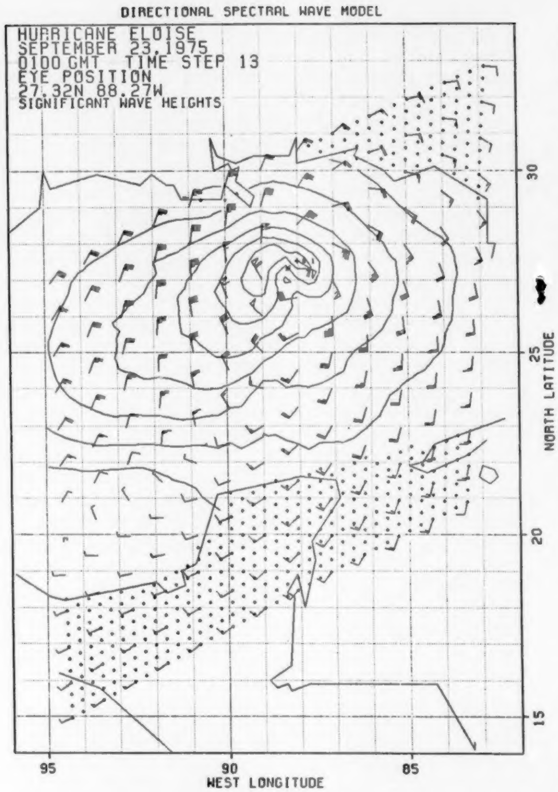

Figure 11.--Contours of significant wave height in the Gulf of Mexico as predicted by the full-scale computer wave model for hurricane Eloise when the highest sea state was observed at the NOAA data buoy. Wind barbs indicate wind direction and speed (kn) computed with the SAIL hurricane wind model. The interval between contours is 1 m. Significant wave height at the buoy (+) was 8.1 m; the location of the eye of the storm is shown by "*". The stipling in the upper right and lower regions are points on the standard grid which were inactivated for this run.

model of hurricane winds has been developed which, using a few parameters to characterize the storm, can reconstruct the wind field everywhere on the grid (Cardone et al., 1976). The characteristic parameters are the latitude and longitude of the eye of the storm, the central pressure depression, the radius of maximum winds, the velocity of the background airflow in which the hurricane is embedded, and the storm's forward velocity. The time evolution of these parameters may be forecast, obtained from aircraft observations, or taken from the historical meteorological record. Figure 8 shows a comparison between model windspeed and observed windspeed at one of NOAA's moored data buoys in the Gulf of Mexico. Hurricane Eloise (1975) passed directly over the buoy, so the observations provide a representative cross section through the storm. Clearly, the wind model has done an excellent job of reconstructing the wind history at this location.

Using winds calculated in this way, we have computed the corresponding wave spectra for a number of historical storms in the Gulf of Mexico and along the U.S. East Coast. Point checks on the validity of these calculations have been made by comparing buoy measurements and aircraft laser altimeter data. An example of such a comparison (fig. 7) shows a frequency spectrum measured by the same buoy which provided the wind history of figure 8 during Eloise. The sea state was at its worst (significant wave height $H_{1/3}$ of about 9 m) at the time this spectrum was acquired. The frequency spectrum predicted by our most highly developed wave model is also shown. The comparison is considered good (model $H_{1/3}$ = 8.1 m).

The model directional spectrum from which the model frequency spectrum of figure 8 was calculated is sketched in figure 9. The most energetic wave component has frequency f = .078 and propagation direction θ = 330°. The model wind at anemometer height at that point and time was 74 kn (fig. 10) (38 m/s) in the direction 300°, 30° to the left of the peak wave direction (as one might expect considering the curvature of the wind field: the spectrum, which should otherwise be asymmetrical about the local wind direction, is colored by energy-generated up-wave, where the wind direction is more toward the north).

Figure 11 shows model contours of significant wave height for the entire Gulf of Mexico at the time the spectra of figures 7 and 8 were computed for the buoy position. The maximum, located at the buoy position, is indicated by "+". The location of the eye, 29 km away from the buoy, is indicated by "*".

Figure 12 compares time histories of significant wave height as predicted by the computer model and measured by the buoy as the storm passed over. Also shown is the evolution of the peak of the frequency spectrum, f_m. Just as $H_{1/3}$ can be used as a gross measure of wave height, f_m can be used as a gross measure of the frequency content of the sea state. It is nearly but not quite the same as the average frequency. For both $H_{1/3}$ and f_m, agreement between computer model and observation is considered satisfactory. Figure 12 also shows the results of a vastly simplified parametrical hurricane wave model developed by SAIL.

THE ROSS PARAMETRICAL HURRICANE WAVE MODEL

In order to account in a physically reasonable way for all the processes affecting wave development and to provide reasonable spectral resolution, computer wave models are necessarily complicated. The calculation which produced the results discussed above approximates the real, continuous ocean-wave spectrum by a discrete set of 312 wave components, each of which must be evaluated at every grid point in the field at every time step. A 24-hr forecast for the Gulf of Mexico, including both wind and wave-field calculations, takes about 2 hr of computing time on a digital computer such as the UNIVAC 1108.

However, in the course of studying data gathered in hurricanes and the output of many computer simulations, Ross (1976) discovered that certain simple relationships seemed to exist between gross parameters of the spectrum, such as significant wave height and peak frequency, and the local windspeed and distance

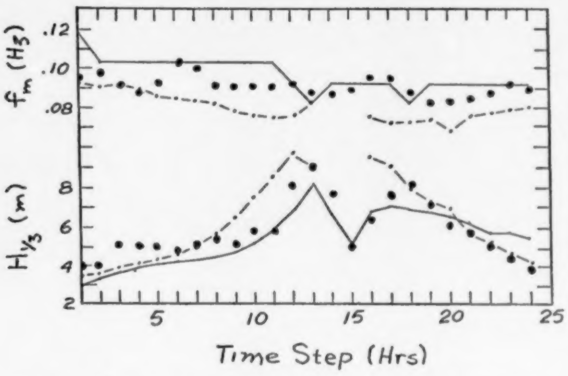

Figure 12.--Comparison of peak frequency f_m and significant wave height $H_{1/3}$ as observed by the NOAA data buoy (•) and as hindcast by the full-scale spectral model (—) and by the Ross parametrical hurricane model (— • —). Eloise passed directly over the buoy at about 0200 on September 23, 1975 (time step 14).

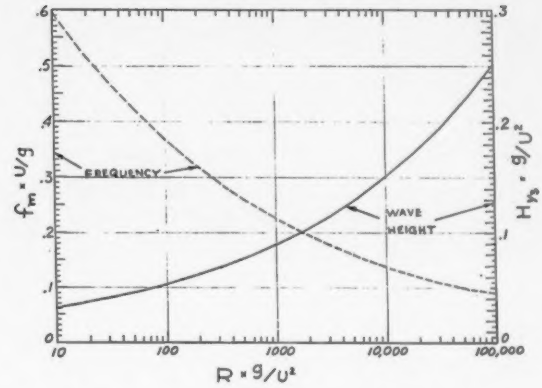

Figure 13.--Ross parametrical hurricane wave model (f_m = frequency spectrum maximum, R = local distance from hurricane eye, U = local windspeed, and the acceleration of gravity $g = 9.8\ m/s^2$ in metric units. Plotting $H_{1/3}$ and f_m against R in these dimensionless forms collapses the entire model into these two curves. This graph may be used to estimate the hurricane wave height and frequency for any location where forecast winds and distance from the storm center are known.

from the eye of the storm. This discovery made it feasible to predict the development of these parameters by hand calculations once the wind field is known, at least for the class of hurricanes which formed Ross's data set.

Ross's model implicitly assumes that all the separate processes which together determine the local sea state (and which individually are accounted for in the full-scale computer models) interact in a similar way from one hurricane to the next, so that the net effect on the local wave field varies only with the scales of the individual storm; that is, with the local windspeed (U) at a given distance from the eye (r). This seems intuitively reasonable since the vortex-like wind fields of hurricanes tend to be geometrically similar from storm to storm, differing primarily in size and intensity. However, individual storms also differ in their translation velocities. This effect is implicitly neglected in Ross's model, although it seems likely (Ross and Cardone, 1978) that significantly different forward speeds do alter the balance of processes maintaining the local wave conditions. The specific forms of the dependence of f_m and $H_{1/3}$ on U and r were fixed by fitting curves to data collected in three hurricanes which differed widely in scale but had similar forward speeds (~15 kn). The results are summarized in the plots of figure 13.

Comparisons between hindcast significant wave height and peak frequency using Ross's method with observations made in hurricane Eloise are included in figure 12. Agreement is surprisingly good considering the gross approximations implicit in Ross's model; indeed, except for the region inside the eye of the storm, where Ross's model does not apply, his calculations seem to match the observations as well as those of the full-scale computer model.

Ross's method is summarized in the two curves of figure 13. These show plots of dimensionless peak frequency ($f_m U/g$) and dimensionless significant wave height ($H_{1/3}\ g/U^2$) versus dimensionless distance from the hurricane eye ($r\ g/U^2$). These quantities are converted to physical units, cycles per s (Hz for Hertz) and m, by multiplying by g/U (frequency) or U^2/g (wave height and distance from the eye), where U is the windspeed in m/s at the point where the wave field is being evaluated, and $g = 9.8\ m/s^2$ is the acceleration of gravity. To illustrate, in the case of hurricane Eloise the worst wave conditions were observed at the buoy at 0100 GMT, when the eye was 29 km away and the local windspeed was 38 m/s. The dimensionless distance from the eye is then:

$$r \frac{g}{U^2} = 29000\ m\ \frac{9.8\ m/s^2}{(38\ m/s)^2} = 197.$$

From figure 13 the dimensionless peak frequency is .32 and the dimensionless significant wave height is .062; to get f_m and $H_{1/3}$, multiply the former by g/U

$$f_m = \frac{9.8\ m/s^2}{38\ m/s} \times .32 = .083\ Hz$$

and the latter by U^2/g

$$H_{1/3} = \frac{(38\ m/s)^2}{9.8\ m/s^2} \times .062 = 9.1\ m$$

which are the values shown at 0100 GMT in figure 12.

The shortcomings of Ross's hurricane wave model are clear, and for fast-moving storms its performance may be significantly poorer than indicated by the Eloise results. Consequently, as a hindcasting tool for computing wave climatology, it is less suitable than the full-scale computer models. In forecasting applications, however, experience has shown that errors in the hurricane wind forecast generally dominate the contribution to wave-forecast error arising from the model's shortcomings. Moreover, the ability to rerun the wave forecast quickly and cheaply as the wind fore-

cast is refined is a significant advantage of Ross's model. For these reasons, it is being implemented, along with SAIL's hurricane wind model, on a computer at the National Hurricane Center (NHC). In the near future, wave forecasts will be incorporated on a trial basis into NHC advisories.

SUMMARY

Modern wave-prediction schemes are based on computer solutions of a mathematical equation describing the evolution of the surface wave directional spectrum under the influence of a specified wind. The spectrum is the fundamental statistical property of the sea state and specifies the distribution of wave energy across the continuum of sinusoidal surface wave components into which the real sea can be mathematically resolved. Once it is known, all other properties of the sea state can be calculated, such as total energy in the waves, average wave height, frequency and propagation direction, maximum probable wave height, and so on. Of these, the quantities which relate most closely to the visual wave observations traditionally taken at sea are significant wave height $H_{1/3}$ (wave height) and peak frequency f_m ($1/f_m$ is comparable with visually estimated wave period).

Wave-prediction schemes may be used with historical wind fields to deduce site-specific wave climate for engineering applications. Driven by forecast winds, they can provide wave forecasts useful for planning marine operations or as part of severe weather warnings.

In order to account for all the processes and constraints affecting wave development in a general way, wave models are necessarily complicated. However, for hurricanes, the geometrical simplicity of the wind field leads to a regular wave-field development which seems adequately characterized by a set of simple relations between $H_{1/3}$, f_m, local windspeed U, and distance from the storm center r. These are shown in graphical form in figure 13. They are presently being used on a trial basis by NHC to compute wave height and period estimates for their hurricane advisories.

Although we can make useful wave predictions at the present state of the art, the situation is still less than completely satisfactory. The primary problem is that the physics of the sources and sinks of wave spectral energy is not well understood. Basic research still needs to be done on how the wind makes waves and how the waves subsequently decay. In addition, new computational schemes are needed to deal more realistically with the effects of nonlinear transfer and to improve the efficiency of the computation. Finally, in practice, no wave-model output can be better than the wind input, and better measurement of oceanic wind fields is needed, if significant improvement in wave forecasting and hindcasting is to be realized. The next generation of oceanographic satellites may provide those measurements. In the meantime, work is already in progress on all fronts, and we look forward to continued improvement in our ability to predict waves.

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AN OCEAN INFORMATION SYSTEM

Mariners Weather Log

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A certain sophistication is missing in our present methods of obtaining weather and oceanographic data, and information vital to operational oceanic analyses can go unreported. Specifically, the lack of nighttime observations, the delay in sending and relaying messages, and the sparsity of data along major shipping routes are undermining the data base and thereby limiting the accuracy of ocean forecasting. Without continuous coverage, explosive developments, such as severe, small-scale storms, can go undetected, and the behavior of existing weather systems is lost. Fortunately, the collection and transmission of ocean observations can be improved greatly by simply using available technology to upgrade shipboard observation programs. Two projects being developed by NOAA using the low-cost cooperative ship program could provide around-the-clock weather observations in the detail that only manned ocean systems can offer. This expanded Ocean Information System not only could provide for rapid collection of weather observations but also could increase the services available to ships.

OBSTACLES IN OBTAINING OCEAN OBSERVATIONS

The proposed Ocean Information System can be better appreciated when compared to the present program. Two major snags in obtaining ocean observations are the lack of a marine-dedicated communication system and the complete dependence on volunteer observers and radio officers to make and transmit messages. Weather data is sent to the National Meteorological Center (NMC) using various communication modes, none of which is dedicated for marine use (fig. 14). This situation is responsible for the long message delay time discussed earlier. CW (Morse code) transmissions, using high and medium radio frequencies, encounter problems with atmospheric interference; the average time for a message to go from ship to NMC is 90 min. The same results are obtained on SSB (single-side-band) voice and radio-telephone transmissions. On the other hand, the average message delay time using satellite communications (fig. 15) is 40 min, which is significantly better than the best time obtained on existing communication systems. The use of satellites for marine purposes is just beginning. Satellites could provide the missing dedicated communication link, and they are integral to the projects now under development.

The drawbacks of relying on volunteer observers and radio officers to furnish mean data are manifest in the World Meteorological Organization's Volunteer Observing Scheme (VOS). Seven-thousand ships participate in VOS, 1,800 of which are managed by NOAA's National Weather Service (NWS). Established observation times for this program are 0000, 0600, 1200 and 1800; few if any observations, however, are actually reported during hours of darkness. To encourage nighttime reporting NWS supports a program to pay a limited number of radio officers for nighttime transmissions. About 80 U.S.-registered ships operating in the Pacific Ocean take part. Radio officers are paid overtime for the 1200 transmission when the ship is in the North Pacific east of the date line. However, payment of overtime does not guarantee that the radio officer will disturb his sleep to send the observation, nor does it assure that the deck officer on watch will make the observation in the first place. The NWS program, which costs about $265,000 a year, yields an average of eight usable 1200 observations per day. This is not much for forecasters to work with considering the vast area of warning responsibility in the Pacific north of the Equator and east of the date line.

Absence of nighttime reports is not the only limitation. Lack of interest and frequent crew changes (observers and radiomen are often unaware that they are in the program) can cause a ship's entire observation

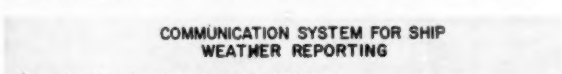

Figure 14.--A schematic of the communication system for reporting ships' weather observations at the present time.

Figure 15.--A schematic of a communication system for reporting ships' weather observations using satellites.

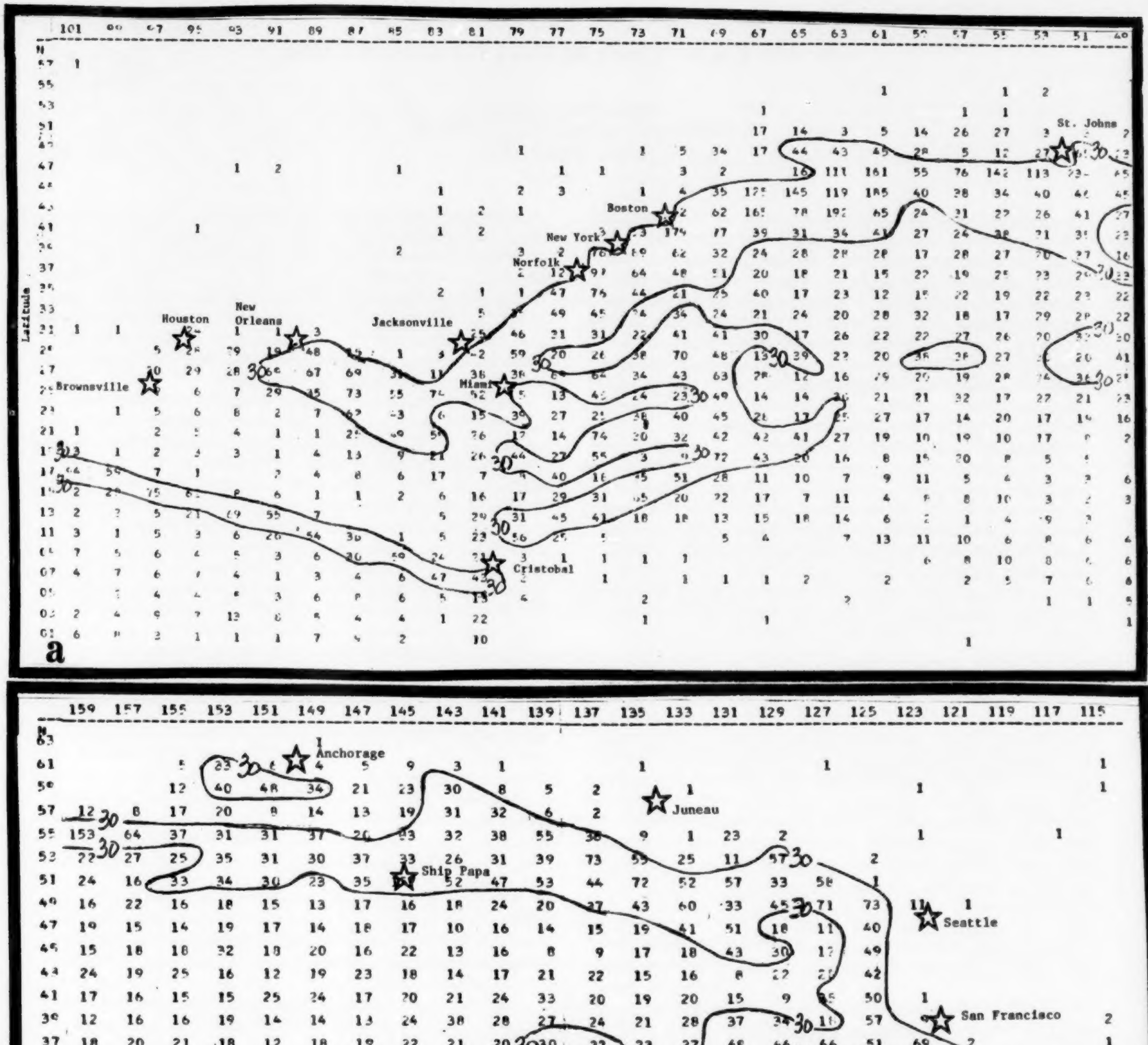

Figure 16.--Computer printout of the number of synoptic ship reports for May 1978 by 2° square for (a) the western North Atlantic and (b) the eastern North Pacific. The identification points are only approximately located to avoid obliterating data. Reports indicated over land are the result of errors in the ships' position, except for reports on the St. Lawrence River.

program to fall by the wayside. Radiomen and observers also tend to drop their reports when the weather is good, and, hence, they think the observation is not needed. They fail to realize that forecasters need all of the information to complete an adequate ocean analysis for preparation of forecasts and warnings.

The two maps in figure 16(a) and (b) show the number of reports received at NMC in Suitland, Md., in May 1978 and give an idea of the reports available (or unavailable) to forecasters. The numbers on the maps represent the total number of reports received from each 2°-latitude by 2°-longitude square during the month. The isolines separate squares with 30 or more reports from the rest of the map (30+ indicating NMC's chance of receiving at least one observation per day in a given area). Since 30 is the minimum number of reports considered adequate for forecasting purposes, the large ocean area outside the 30 or more isoline clearly demonstrates the need for data, even along heavily traveled shipping routes.

MANNED VERSUS UNMANNED OCEAN SYSTEMS

Seagoing vessels are not the sole generators of ocean data, but they are superior to satellites and unmanned ocean platforms for obtaining detailed weather reports. Data buoys equipped with sensors for measuring wind, pressure, and temperature (air and water) are sufficient for use in large-scale models, but not adequate for regional analysis and forecasting. Satellites are excellent for the portrayal of cloud imagery, but do not provide the information required for detailed surface analysis. In other words unmanned ocean systems cannot produce the visual details accessible to the shipboard or offshore platform observer. Elements that are difficult to measure by unmanned systems include sea state, when a wind wave and several swell trains are occurring at the same time; current and past weather; cloud conditions; and visibility. Data buoys and satellites are expensive to buy and operate in comparison to shipboard observation programs. The cost of a data buoy with a weather package is about $350,000, excluding buoy operation and ship support. In contrast, the entire NOAA cooperative ship program is run on less than the cost of three data buoys. Considering this as well as the present superiority of manned ocean systems for supplying detailed weather observations, improving the collection of weather and oceanographic data can be a relatively simple matter of applying new technology to shipboard observation programs.

SEAS/GREEN THUMB

Two systems concepts that would better use the ship weather observing platform are the Shipboard Environmental Data Acquisition System (SEAS) and the NOAA/DOA Computer/TV Information System (nicknamed GREEN THUMB).

SEAS is a shipboard automatic station which collects and transmits weather and oceanographic data. It includes a manual entry device for manually observed weather elements (visibility, weather, sky cover, sea conditions, and special remarks) and uses the Geostationary Environmental Satellite (GOES) system for transmitting data. SEAS by itself has no receive capability, but GREEN THUMB (which would be used in conjunction with SEAS) receives and displays forecasts and technical data upon request.

GREEN THUMB is a system for presenting weather, forecasts, and agricultural information on a home TV screen via telephone. A control and recording device (GREEN THUMB) must be connected to the TV antenna terminals. For agricultural use the user dials a number at the local County Extension Agent's office and places the handset in the telephone cradle of the control and recording device.

The GREEN THUMB is connected to a microcomputer at the local office, which in turn is connected to a master computer at NWS. A numbered table of contents is displayed on the TV screen. By pushing the appropriate key on the control box, the desired information is transmitted at high speed into the memory of GREEN THUMB. The telephone can now be disconnected and the recording played at any convenient time. A National Weather Service and Department of Agriculture pilot study is planned.

At first, alphanumeric forecast products now prepared would be made available to ships. Further development would be needed to add maps and other graphics to the display.

Together, SEAS and GREEN THUMB form the proposed Ocean Information System (OIS). A flow diagram for a high-seas OIS is shown in figure 17. This system would move ship environmental data to shore and service products to ships via GOES or MARISAT satellite communications. A version using phone lines applic-

HIGH SEA OIS

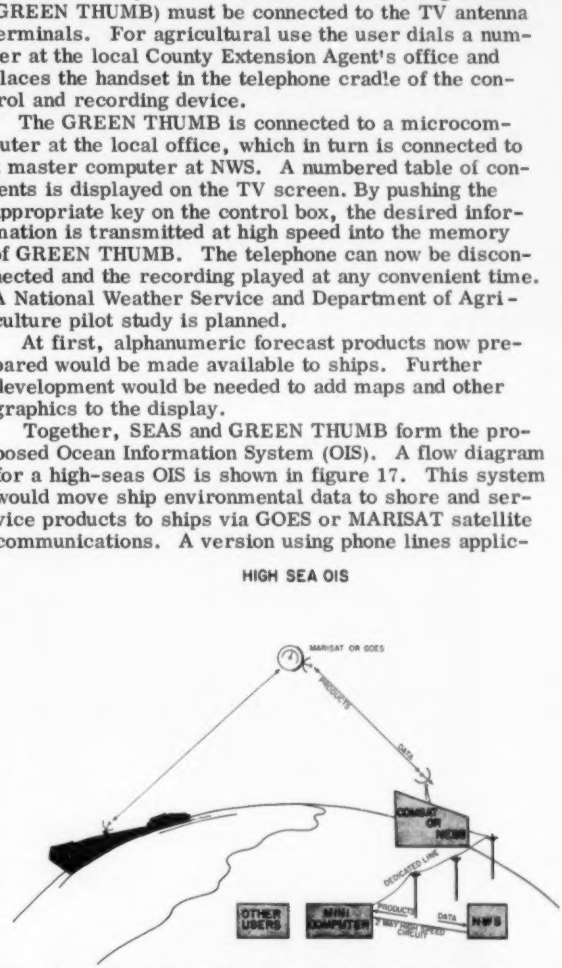

Figure 17.--Proposed Ocean Information System.

GREAT LAKES OIS

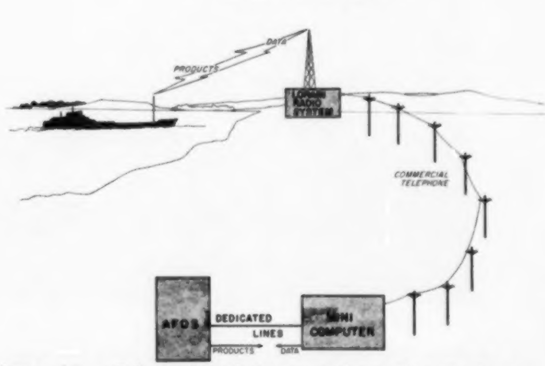

Figure 18.--Schematic of Ocean Information System for the Great Lakes.

able to the Great Lakes is shown in figure 18. The Great Lakes system is less complicated because service products are required for a relatively small area, and ship observations can be entered manually.

SUPPORT FOR AN OCEAN INFORMATION SYSTEM

NOAA has a grant to develop a prototype SEAS package, and budget support has been provided for developing GREEN THUMB in fiscal year 1979. The combination of these two projects for maritime use would expand the capability of the marine observation program as well as increase services available to ships. Shipboard computer storage available through OIS would make it possible to display weather forecasts, navigational aids, port conditions, tidal data, and other information designed for ship safety. Ships would also be able to contact shoreside centers for assistance during emergencies. The technology is now available for development of a system much like that used in aviation for air traffic control. For the sake of economy and safety, it is imperative that the marine industry and government make a concerted effort to develop the ideal Ocean Information System.

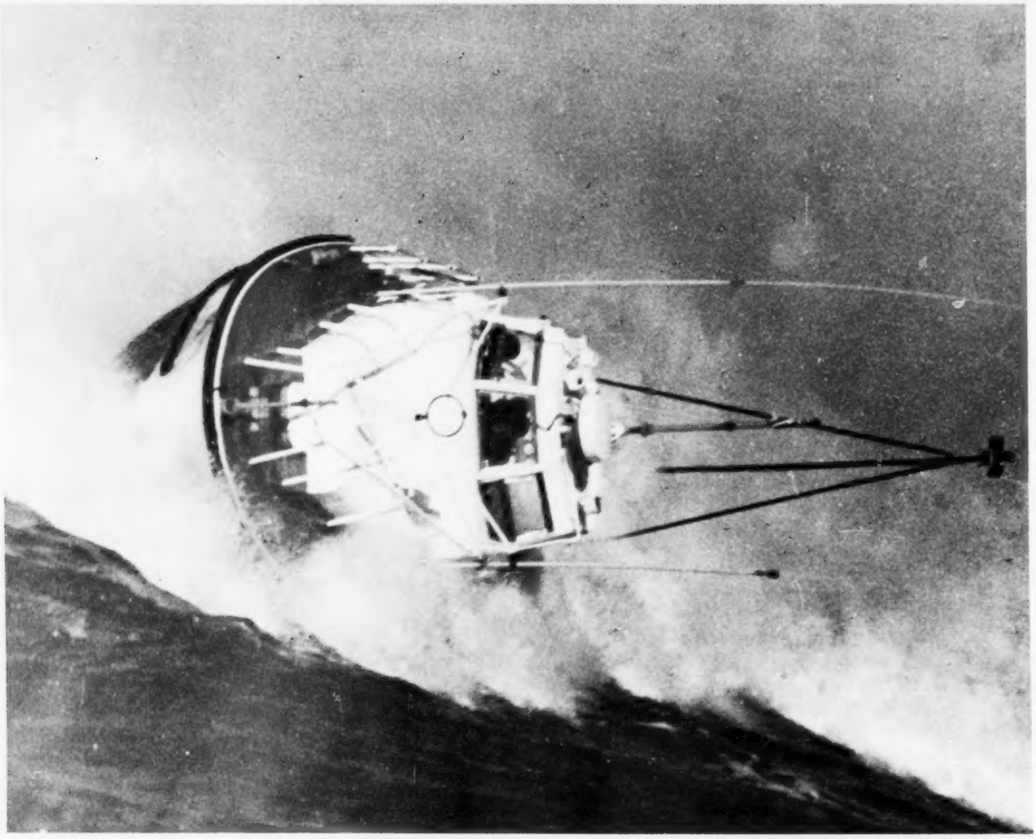

Figure 19.--A spectacular roll of nearly 90 degrees. This Coast Guard 44-ft motor lifeboat is tender and was designed to recover from such rolls in heavy surf at the Columbia River bar. U.S. Coast Guard Photo.

THE COLUMBIA RIVER BAR

Mariners Weather Log

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Nearly 100 years ago, the mouth of the mighty Columbia River between Washington and Oregon was the scene of a maritime tragedy that continues to haunt helmsmen of modern-day fishing vessels and pleasure craft who venture near the shoals (fig. 19). On May 4, 1880, an entire fleet of small salmon-fishing boats suddenly was caught in gale-force winds blowing in from the Pacific Ocean. One by one, the small vessels lost the battle with the pounding seas and never returned to port.

During the past two and a half centuries, more than 100 sea captains who chose to defy nature's warning signals--dense fog, violent winds, and roaring breakers--have earned the dubious distinction of a permanent berth in the "graveyard of the Pacific," upon trying to cross over the Columbia River bar.

From stately three-masted schooners and barks, loaded with Northwest lumber, furs, grain, and cement, to clumsy fishing junks, swept eastward by the strong Japanese current, the wrecks remain an ever-present reminder of the Columbia's cargo of shifting sands.

The Columbia River rises in British Columbia, Canada, through which it flows for some 425 statute mi before entering the continental United States in northeast Washington. Thence it flows south to its

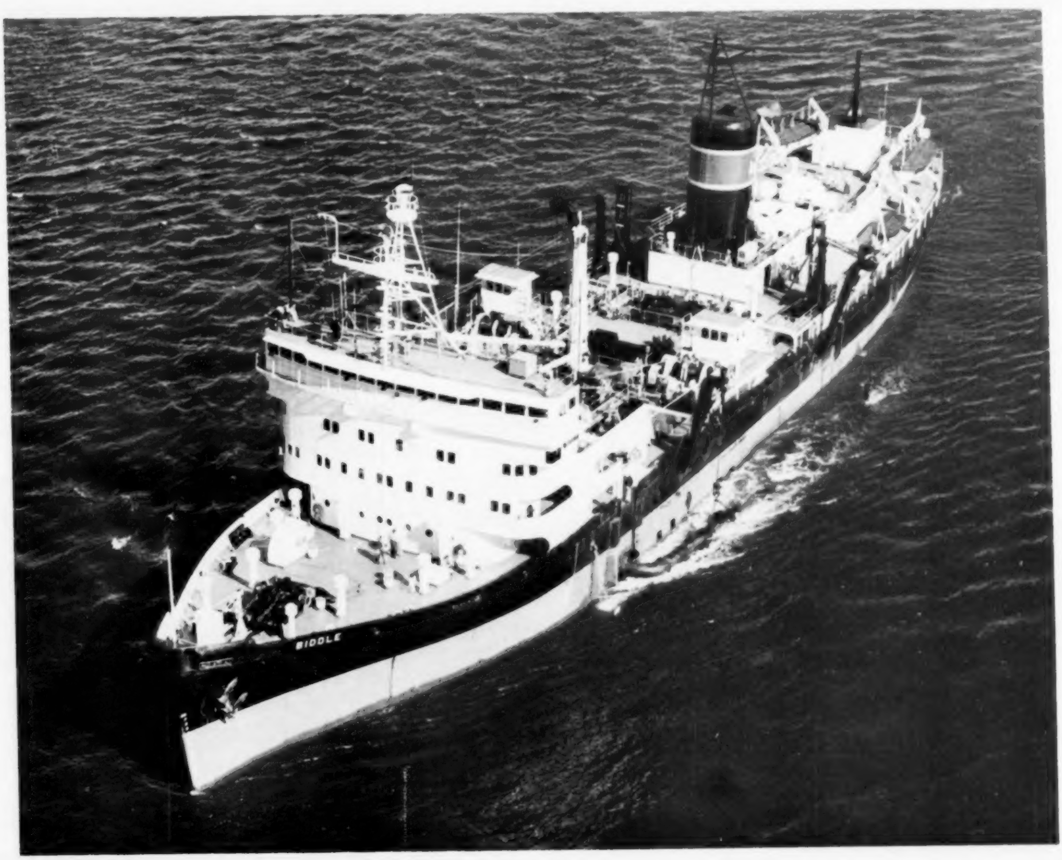

Figure 20.--The hopper dredge BIDDLE has the responsibility for maintaining the 48-ft-deep entrance channel at the mouth of the Columbia River. The BIDDLE is operated by the Corps of Engineers.

junction with Snake River, from which it curves west and forms the boundary between Washington and Oregon for the remainder of its course to the Pacific Ocean. The U.S. part of the river is 745 mi long. Between the Cascade Mountains, the river flows through a canyon averaging about 5 mi wide between high cliffs on each side; of this width the river occupies about 1 mi, the rest being marsh, low islands, and lowlands. Near the mouth the river becomes wider and in some places is 5 mi across. The river is navigable by deep-draft vessels to Vancouver, Wash., and Portland, Oreg. Barges navigate the Columbia River to Pasco and Kennewick, Wash., 329 mi above the mouth.

The Columbia River Lightship (46°11.1'N, 123°11'W), with red hull and the name COLUMBIA in large white letters on the sides, is 5.3 mi off the entrance and on the entrance range line; the light is 55 ft above the water. A radiobeacon and fog signal are at the lightship. The code flag signal and radio call is NNCR.

Since the construction of manmade jetties, the deepening and widening of the river channel by the U.S. Army Corps of Engineers (fig. 20), and the implementation of more modern methods of weather prediction and communication by NOAA, the toll of lives and ships has diminished dramatically. Federal project channel depths in the Columbia River are 48 ft over the bar, then 40 ft from the confluence of the Willamette and Columbia Rivers through the lower turning basin at Vancouver, and 27 ft to the port terminal facilities at The Dalles.

However, the treachery of the river's current as it meets the oncoming ocean tide, accompanied by frequent winds from the southwest, continues to be a threat to human life and property that precipitates hundreds of search-and-rescue missions by the U.S. Coast Guard (fig. 21). The Columbia River bar is very dangerous because of sudden and unpredictable changes in the currents often accompanied by breakers. It is reported that ebb currents on the north side of the bar attain velocities of 6 to 8 kn and that strong northwesterly winds sometimes cause currents that set north or against the wind in the area outside the jetties.

Figure 21.--The U.S. Coast Guard's Cape Disappointment Station is the largest lifeboat station in the country and the busiest one on the West Coast. U.S. Coast Guard Photo.

In the entrance the currents are variable, and at times reach a velocity of over 5 kn on the ebb; on the flood they seldom exceed a velocity of 4 kn. The current velocity is 3.5 kn, but this tidal current is always modified both as to velocity and time of slack water by the river discharge. On the flood there is a dangerous set toward Clatsop Spit, its direction being approximately east-southeast; on the ebb the current sets along the line of buoys. Heavy breakers have been reported as far inside the entrance as south of Sand Island.

For example, on September 13, 1976, the PEARL-C, a charter fishing boat carrying 10 persons, capsized and sank on a windy, rainy night while being towed across the Columbia River bar by a Coast Guard motor lifeboat. Two persons were rescued, one drowned, and seven others, including the vessel's operator, were never found.

As a result of a thorough investigation of that accident by the National Transportation Safety Board, NOAA was asked to "develop an oceanographic measurement system to measure, process and report those sea conditions which are important to the safe navigation of boats crossing the Columbia River bar."

To meet this challenge, scientists with the Pacific Marine Environmental Laboratory (PMEL) in Seattle, Wash., are cooperating with the National Weather Service and other government agencies--including the Coast Guard and Corps of Engineers--to implant wave-rider buoys on the Columbia River bar. The buoys, approximately 1 m in diameter, will gather wave height and length data on site and relay the information to shore-based equipment which will tape and reduce the data.

In addition, a time-lapse camera will photograph a conventional radarscope which will be mounted at Cape Disappointment, Wash. The radarscope pictures will provide information on the two-dimensional structure of the wave field timed with the wave-rider buoy measurements in the entrance channel. This information will be interpreted by PMEL and the Corps' Coastal Engineering Research Center, as part of the Columbia River entrance channel study.

To augment this information, the Corps is conducting a motion study of deep-draft ships as they enter and leave the rough waters of the Columbia River bar. Two hundred pounds of electronic equipment will be placed on Chevron Oil and Weyerhaeuser Timber Company vessels to record the ships' movements as they negotiate the narrow entrance channel. The equipment will remain on the ships for a year as they ply the waters between Everett, Wash., in Puget Sound and the Pacific Coast, then 100 mi inland to Portland, Oreg., on the Columbia River, and on down the coast to Coos Bay, Oreg., and San Francisco, Calif.

Since the Columbia River Bar Pilots organization was established in 1847, every foreign vessel and every large American ship whose master is not licensed must employ one of the 18 experienced bar pilots to guide the ship through the shoals and upriver to its destination. In 1977, the pilots made 4,600 passages in and out of the river's entrance.

As a result, no deep-draft vessel has been wrecked on the sands since the CAPTAYANNIS, a Greek freighter, grounded on the shoals on October 22, 1967, while trying to negotiate the channel without the services of a Columbia River bar pilot.

But there are hundreds of smaller vessels that de-

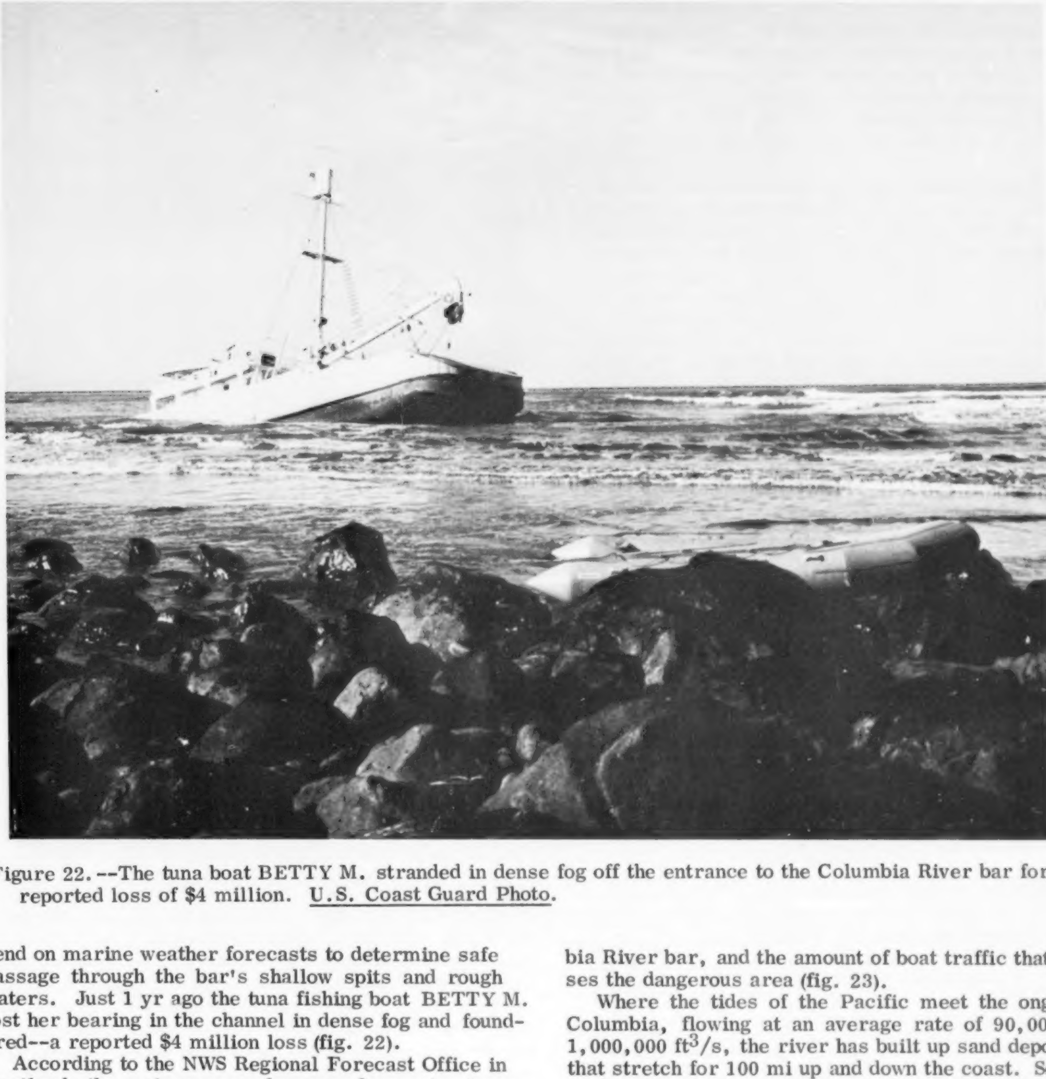

Figure 22.--The tuna boat BETTY M. stranded in dense fog off the entrance to the Columbia River bar for a reported loss of $4 million. U.S. Coast Guard Photo.

pend on marine weather forecasts to determine safe passage through the bar's shallow spits and rough waters. Just 1 yr ago the tuna fishing boat BETTY M. lost her bearing in the channel in dense fog and foundered--a reported $4 million loss (fig. 22).

According to the NWS Regional Forecast Office in Portland, the main concern for wave forecasts at any river bar leading into the ocean is at ebb tide. By calculating when the falling tide occurs and applying this information to wave data fed into a computer at Oregon State University, the NOAA meteorologists issue wave forecasts twice daily--at 10:30 a.m. and at 10:30 p.m.--via NOAA Weather Wire to press and to weather offices in the region. The Coast Guard station at Astoria, Oreg., then broadcasts this information on very high frequency radio to all vessels in the area.

Because the sands in the bar shift all the time, the NWS Forecast Office in Portland also receives on-site wave condition observations from the Coast Guard's motor lifeboat station at Cape Disappointment north of the entrance. To understand the need for such information, one must visualize the geography of the Columbia River bar, and the amount of boat traffic that crosses the dangerous area (fig. 23).

Where the tides of the Pacific meet the ongoing Columbia, flowing at an average rate of 90,000 to 1,000,000 ft^3/s, the river has built up sand deposits that stretch for 100 mi up and down the coast. South of the Columbia River entrance lies Clatsop Spit, a shallow crescent of sand that caused the grounding of many ships before the completion of a 5-mi-long jetty in 1894 (fig. 24). North of the entrance stretch the fingers of Peacock Spit, another treacherous shallow area, backed by the towering rocky promontories of Cape Disappointment and North Head. Cape Disappointment Light (46°16.6'N, 124°03.1'W), 220 ft above the water, is shown from a 53-ft white conical tower, with white horizontal band at top and bottom and black horizontal band in the middle, on the extreme southeastern point of the cape; a radiobeacon is at the station.

After the agency that later became NOAA's National Ocean Survey recommended a manmade extension north of the river's entrance, construction of a 2-mi

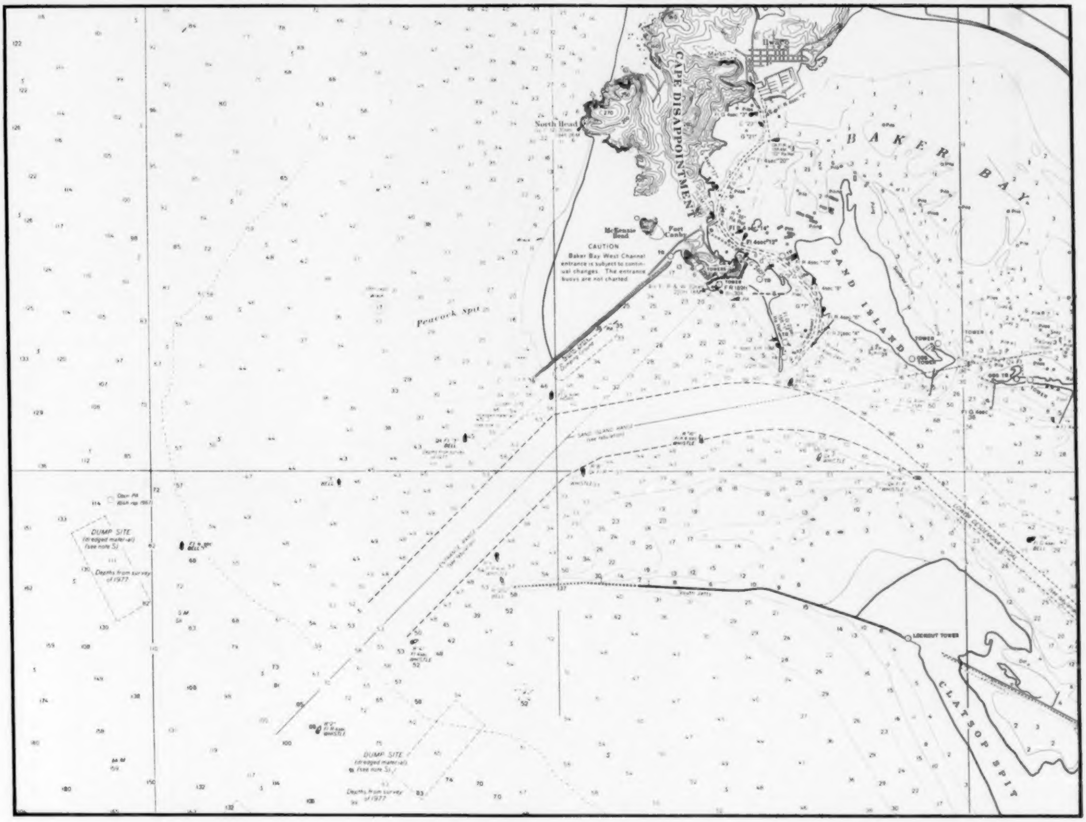

Figure 23. --A portion of National Ocean Survey Chart 18521 showing the landmarks and hydrography at the entrance to the Columbia River.

jetty westward toward the open Pacific was completed in 1915. The jetty shields vessels entering the Columbia River from the menacing Peacock Spit.

The offshore current is a combination of the tidal current, the outflowing current from the Columbia River, and the wind-driven current. The wind-driven current on a given day is determined by the magnitude and direction of the wind over the preceding several days. The currents are variable and uncertain. Velocities of 3 to 3.5 kn have been observed between Blunts Reef and Swiftsure Bank, and velocities considerably in excess of those amounts have been reported. Under such conditions, vessels should keep outside the 30-fathom curve until the lightship has been made. Care should be taken not to mistake the low sand beach north of Cape Disappointment for that south of Point Adams. Nearly all the vessels which have gone ashore attempting the entrance have been wrecked north of the mouth in the vicinity of Peacock Spit.

Because of jetty locations and tidal currents, sea conditions on the bar can change rapidly with time and location. Furthermore, it is difficult from the seaward side to determine conditions on the bar since the front of the waves or breakers cannot be seen. In the daytime, when visibility is adequate, it is possible to get a report from the watchtower at Cape Disappointment, but at night there is no way except venturing on the bar to determine actual conditions. As a result, small boats generally rely on direct observation of the sea conditions and gamble on a safe crossing.

In fog or darkness there is no suitable means of determining actual conditions with enough precision to assure that small boats can cross safely. For this reason the wave-rider buoy could play an important role in future marine weather forecasts. One of NOAA's aims in improving the marine weather forecasts is to reduce the number of search-and-rescue missions the Coast Guard is called upon to conduct.

In the meantime, the Cape Disappointment Motor Life Boat Station is the largest lifeboat station in the U.S. Coast Guard and the busiest station on the West Coast. The number of small boats plying the waters between Memorial Day and Labor Day is very large. According to the Coast Guard Air Station at Warrenton, Oreg., near Astoria, it is not uncommon to have 400 boats off the mouth of the Columbia River bar within a 5-mi radius and 1,500 boats within a 15-mi radius in July or August or on weekends. Between Tillamook Head, Oreg., and Grays Harbor, Wash., a distance of 65 coastline miles, there may be as many as 4,000

Figure 24.--Jetties at the Columbia River entrance channel help ships over the hazardous bar and help maintain a 48-ft entrance depth. This is the south jetty as seen from the ocean. Constructed in 1894, it curves to join the land at Clatsop Spit. U.S. Coast Guard Photo.

boats on a summer weekend.

As a result, the Coast Guard air station southeast of the bar makes about 250 search-and-rescue missions per year with its three HH-3F "jolly green giant" helicopters and averages more than 600 hr of flight time during June and July. Last year, the Coast Guard's Cape Disappointment Motor Life Boat station across the bar on the north recorded 823 search-and-rescue missions. Of that number, 680 occurred between June and September. And the station estimates that approximately 2,400 people were assisted, 75 lives were saved, and $15.5 million in property was salvaged. In 1976 the same station assisted 2,963 people, saved 108 lives, and salvaged $39.9 million in property.

By law, the Coast Guard provides assistance for life and property in jeopardy along U.S. coasts. Usually, a boat drifts into the vicinity of a hazardous bar with its motor turned off while fishing, is then unable to start the engine, and the Coast Guard is called to tow the boat out of danger. During summer most of the search-and-rescus missions are typically for 24-ft pleasure craft. On weekends the Coast Guard stations' radios are constantly busy, and the activity only subsides between 11 p.m. and 4 a.m.

To meet these needs, the Coast Guard has a motor lifeboat in the water at all times between 4 a.m. and late evening for quicker rescue service. On many occasions all seven Coast Guard lifeboats have been in service at once.

Because of increased marine traffic nationwide and, particularly, a sharp rise in the boating activity among small vessels around the mouth of the Columbia River, NOAA is required to maintain a close watch on the environment and fulfill a need for more precise weather forecasting and other services. The overall objective is to enhance the safety of life and property at sea and in particular around heavy traffic areas such as port and harbor entrances like the Columbia River bar. The project is part of a larger program of NOAA's Ocean Services Division to augment similar programs at other ports and harbors around the country.

The Columbia River bar wave-rider buoy project is one step toward making NOAA's overall objective a reality.

ACKNOWLEDGMENTS

This article first appeared in NOAA Magazine in October 1978. Additions to the article were obtained from National Ocean Survey's U.S. Coast Pilot No. 7, Pacific Coast.

THE MARINERS WEATHER LOG WELCOMES ARTICLES AND LETTERS FROM MARINERS RELATING TO METEOROLOGY AND OCEANOGRAPHY, INCLUDING THEIR EFFECTS ON SHIP OPERATIONS.

Hints to the Observer

SHIP'S WEATHER OBSERVATIONS FORM

(A REMINDER)

The address for forwarding your completed NOAA Form 72-1, Ship's Weather Observations, has been changed to:

National Climatic Center/NOAA
Federal Building
Asheville, NC 28801

Each ship captain should have received a letter from the Marine Program Leader, National Weather Service, explaining the change and containing a supply of preaddressed envelopes. Supplies of new envelopes can be obtained from any Port Meteorological Office.

This new procedure will speed delivery of the forms to the National Climatic Center, where they are archived and used for many climatological purposes.

The Port Meteorological Officer will have more time to visit ships and observers. He will still keep your ship supplied with observing materials and inspect observing equipment. The marine weather observations of the Cooperative Ship Program are essential to the worldwide weather program and especially for the immediate marine forecast. Good forecasts are difficult to make, but without good observations they would be impossible.

GULF STREAM BULLETINS

Figure 25 is an actual Gulf Stream bulletin as it was transmitted over the teletype circuits. The bulletin was accidently included with other weather bulletins which the Editor receives daily.

```
PTTUZYUW RUEOLMA0015 3351610+UUUU++RUCLFOA RULYWCA RUCLFLA RUCLEKA
RULYSGG.
ZNR UUUUU
P 011605Z DEC 78
FM NATIONAL ENVIRONMENTAL SATELLITE SERV WASHINGTON DC
TO RUCLFOA/CGRADSTA MIAMI CCGD7
RULYWCA/CGCOMMSTA PORTSMOUTH
RUCLFLA/NAVOCEANO BAY ST LOUIS MISS. CODE 3710
RUCLEKA/PATRON FOUR NINE
RULYSGG/COMDESRON TWO TWO
BT
UNCLAS CMNESC

GULF STREAM LOCATION - THE LINE DESCRIBED BY THE FOLLOWING
SEQUENCE OF POINTS REPRESENTS THE WEST WALL OF THE GULF STREAM.

27.0/80.0  28.4/80.1  29.5/80.2  30.2/80.1
31.1/79.7  35.1/75.2  35.6/74.3  36.6/73.2
36.9/72.2  37.3/69.7  38.7/69.0  38.8/68.5
37.4/65.7  37.9/64.5

THE MAXIMUM CURRENT OF THE GULF STREAM LIES BETWEEN 12-15MILES
SEAWARD OF THIS LINE. LATEST SATELLITE DATA.. 12/1/78  0900Z
BT
+0015
```

Figure 25.--Actual Gulf Stream bulletin based on December 1, 1978, satellite data.

Tips to the Radio Officer

Thomas H. Reppert
National Weather Service, NOAA
Silver Spring, Md.

CORRECTIONS TO WORLDWIDE MARINE WEATHER BROADCASTS (July 1977 Edition)

Insert station:
3-0305
Esquimalt, British Columbia CKN
Frequency (kHz) 4497.5, 6946, 12125

Time	Map area	Contents	Remarks
0215		Test pattern	Mon-Fri
0230	A	24-hr surface prognosis	" "
0330	A	Surface analysis	" "
1500		Test pattern	" "
1515	A	24-hr surface prognosis	" "
1530	A	Surface analysis	" "
2100		Test pattern	Daily
2115	A	24-hr surface prognosis	"
2130	B	24-hr wave heights	"
2145	A	Surface analysis	"
2200	C	72-hr surface prognosis	"

Map Areas

A - 63°N,179°E	36°N,160°W	55°N,92°W	38°N,118°W
B - 46°N,177°W	28°N,157°W	63°N,121°W	37°N,122°W
C - 58°N,165°E	30°N,141°W	39°N,25°W	20°N,68°W

Each transmission is preceded by 2 min of phase white signal.

CORRECTIONS TO RADIO STATIONS ACCEPTING SHIPS' WEATHER AND OCEANOGRAPHIC OBSERVATIONS

Page 6. Insert station:

WPD Tampa, FL 420 4274 6446 8473 13051.5 17170.4
Station hours: 1200-2200.

Page 18. Delete call sign XXU, S. Vicente de Cabo. Insert D4A.

GREAT LAKES WEATHER BROADCASTS

1. Scheduled Broadcasts (coded MAFOR). Unless indicated otherwise, these coded forecasts are broadcast at 6:02 and 12:02 EST a.m. and p.m.

City	Radio Station	Frequency (channel)
Lorain, Ohio	WMI	26 4415.8, 8783.2 kHz
Duluth, Minn.	KVY601	84
Ontonagon, Mich.	KIL922	87
Copper Harbor, Mich.	KVY602	84
Grand Marais, Mich.	KVY603	87
Pickford, Mich.	KIL923	84
Sturgeon Bay, Wis.	KVY604	87
Port Washington, Wis.	KVY605	85
Benton Harbor, Mich.	KIL924	87
Algonac, Mich.	KIL927	87
Alpena, Mich.	KIL925	87
Harbor Beach, Mich.	KIL926	84
Oregon, Ohio	KIL928	84
Ripley, N.Y.	KIL929	84
Rogers City, Mich.	WLC	26* 2514, 4382.2 kHz
Sault Ste. Marie, Mich.	WLC	26*
Tawas City, Mich.	WLC	26*
Charlevoix, Mich.	WLC	26*

*Broadcast times for these cities, 6:17 and 12:17 EST a.m. and p.m.

2. U.S. Coast Guard Scheduled Broadcasts. These plain-language forecasts and warnings are broadcast on channel 22.

City	Radio Station	Times
Buffalo, N.Y.	NMD-47	0255, 0555, 0855, 1155, 1455, 1755, 2055, 2355
Duluth, Minn.	NOG-14	0135, 0435, 0735, 1035, 1335, 1635, 1935, 2235
Sault Ste. Marie, Mich.	NOG	0005, 0305, 0605, 0905, 1205, 1505, 1805, 2105

REVISED CALLING PROCEDURE FOR LOOP CURRENT BULLETIN

This is the revised call-up procedure to access the Loop Current Bulletin from the Western Union FY1:

1. Telex users dial 8513, TWX users dial 710-988-5956;
2. Pause for exchange of answerbacks;
3. Type LOOP. The WU FY1 system will then send the message.

ACKNOWLEDGMENTS

Thanks to R/O George H. Anderson, SS DELTA URUGUAY, for recent information relative to the marine weather program.

Hurricane Alley

Dick DeAngelis
Environmental Data and Information Service, NOAA
Washington, D.C.

NORTH INDIAN OCEAN
SEPTEMBER AND OCTOBER 1978

Just one tropical storm developed during this 2-mo period. On the average two tropical cyclones develop, one of which reaches hurricane intensity. However, just one tropical storm developed last year during this period also.

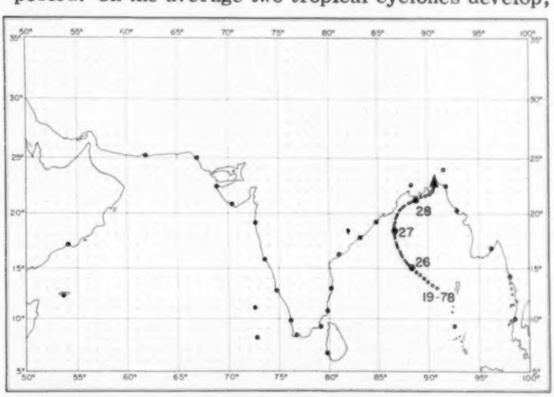

Figure 26.--Bay of Bengal tropical cyclone 19-78 October 26-28, 1978.

Tropical cyclone 19-78 (fig. 26) came to life just west of the Andaman Islands on the 25th. The system traveled northwestward before recurving toward the northeast on the 27th. Winds near the center reached a peak of close to 50 kn on the 26th. The storm weakened and broke up near the Mouths of the Ganges.

SOUTHERN HEMISPHERE
SEPTEMBER AND OCTOBER 1978

No tropical cyclones roamed these waters during the spring months. As the records indicate (table 2), only 10 storms have been spotted during the past 13 yr.

1966 GLOBAL TROPICAL-CYCLONE ACTIVITY

Activity in 1966 was very close to normal (tables 2 and 3). None of the basins were either way above or below normal. September, usually the most active month, was overactive with 19 tropical cyclones. This can be traced to an abundance of storms in both

Table 2.--Tropical cyclones, 1965 to 1977

Month	North Atlantic	Eastern North Pacific	Western North Pacific	North Indian	South Indian	Australia-South Pacific	Total	Average
January	0(0)	0(0)	9(5)	2(1)	29(17)	52(20)	92(43)	7.1(3.3)
February	0(0)	0(0)	4(1)	0(0)	30(16)	41(16)	75(33)	5.8(2.5)
March	0(0)	0(0)	6(1)	0(0)	15(5)	39(18)	60(24)	4.6(1.8)
April	0(0)	0(0)	11(9)	4(2)	6(1)	18(6)	39(18)	3.0(1.4)
May	3(1)	5(3)	14(10)	14(5)	3(0)	4(3)	42(22)	3.3(1.7)
June	8(4)	24(9)	20(13)	5(1)	0(0)	0(0)	59(27)	4.4(2.1)
July	13(7)	41(16)	60(35)	2(0)	1(0)	2(0)	119(58)	9.2(4.5)
August	32(22)	53(31)	67(38)	2(1)	0(0)	0(0)	154(92)	11.8(7.1)
September	44(26)	41(20)	63(43)	11(4)	1(0)	0(0)	160(93)	12.3(7.2)
October	20(12)	20(10)	50(40)	16(7)	5(3)	4(1)	115(73)	8.8(5.6)
November	4(2)	4(0)	34(19)	19(8)	5(2)	18(7)	84(38)	6.5(2.9)
December	1(0)	0(0)	11(4)	11(4)	21(6)	33(15)	77(29)	5.9(2.2)
Total	125(74)	188(89)	349(218)	86(33)	116(50)	211(86)	1,075(550)	
Average	9.6(5.7)	14.5(6.8)	26.8(16.8)	6.6(2.5)	8.9(3.8)	16.2(6.6)	82.7(42.3))	
Percent hurricane	59%	47%	63%	38%	43%	41%		

Table 3.--Global tropical cyclones originating in 1966

Month	North Atlantic	Eastern North Pacific	Western North Pacific	North Indian	South Indian	Australia S. Pacific region	Total
January						4 (1)	4 (1)
February					1	3 (1)	4 (1)
March					2	4 (1)	6 (1)
April			1 (1)	1 (1)			2 (2)
May			2 (2)				2 (2)
June	1 (1)	1 (1)	1 (1)				3 (3)
July	4 (3)		5 (3)				9 (6)
August	1 (1)	4 (4)	8 (6)				13 (11)
September	4 (1)	6 (2)	7 (4)	2			19 (7)
October		2	3 (2)				5 (2)
November	1 (1)		2	4 (1)		2 (1)	9 (3)
December			1 (1)	1	3 (1)	2	7 (2)
Total	11 (7)	13 (7)	30 (20)	8 (2)	6 (1)	15 (4)	83 (41)

Note: The numbers in parentheses indicate tropical cyclones that reached hurricane intensity (winds ≥64 kn).

the eastern and western North Pacific.

Table 2, which summarizes the records for a 13-yr period, has been updated since our November 1978 issue. The reason for this change is a counting change in the North Atlantic Ocean. The National Hurricane Center has decided to include subtropical storms along with the tropical cyclones. Many systems of subtropical origin actually become tropical (warm core) cyclones. It was felt in earlier years that these subtropical systems were simply part of the tropical-cyclone records, and statistical tests seem to bare this out.

On the Editor's Desk

NATIONAL CLIMATE PROGRAM OFFICE FORMED

Improved assessment of climatic effects upon crops, energy, transportation, natural resources, and other major national concerns will be sought by a new U.S. National Climate Program Office.

Establishment of the interagency office within NOAA is the first step in activating the National Climate Program Act, which was signed into law by President Carter on October 31, 1978. At the signing, the President said he was "pleased to commit the Nation to this program of improving our understanding of climatic changes, both natural and man-induced."

The new office will provide leadership and coordination for a broad program of research, observations, assessments, and services involving State and numerous Federal agencies in a concerted effort to deal more effectively with changes in climate. The Earth's climate is so complex that it may never be fully understood, but the new program will bring about the kind of concerted effort that will allow scientists to work toward anticipating such phenomena as droughts, extreme cold spells, and above-average rainfall.

The program provides for working with States, universities, and research centers to enhance the understanding of climate. It calls for:

- assessment of climatic effects on crop yield, raw materials, fibers, energy demand, transportation, and land and water resources;

- basic and applied research into the chemical, archeological, physical, biological, and historical aspects of climate changes;

- establishment of experimental climate forecasting centers; and

- increased international cooperation in climate research, monitoring, analysis, and dissemination of data.

The program will be funded by the participating Federal agencies which include NOAA, the Departments of Agriculture, Defense, Energy, Interior, State, and Transportation, the Environmental Protection Agency, NASA, and the National Science Foundation.

CONTINENTAL SHELF SLIDES FOUND NEAR OIL EXPLORATION AREA

Massive underwater avalanches of sediment are still occurring on the continental slope and rise off the Atlantic's Baltimore Trough, which could complicate petroleum development there.

Until now, geologists have not been sure precisely when large submarine slides in the area had occurred, and if they were continuing to take place--an important factor in evaluating offshore drilling sites for petroleum exploration. Analyses of actual seafloor cores indicate that some sediment upheaval took place during the Ice Age, but additional observations show that mass movement of the uppermost sediment layer on the continental slope has occurred in relatively recent times up to the present.

These conclusions are based on extensive analyses of seafloor core samples and seismic reflection profiles collected in a 60-km by 120-km underwater corridor about 60 mi east of Atlantic City, N.J., seaward of the Baltimore Canyon petroleum exploration region (fig. 27).

Twenty-two hundred nautical miles of geophysical data and several seafloor core samples were gathered

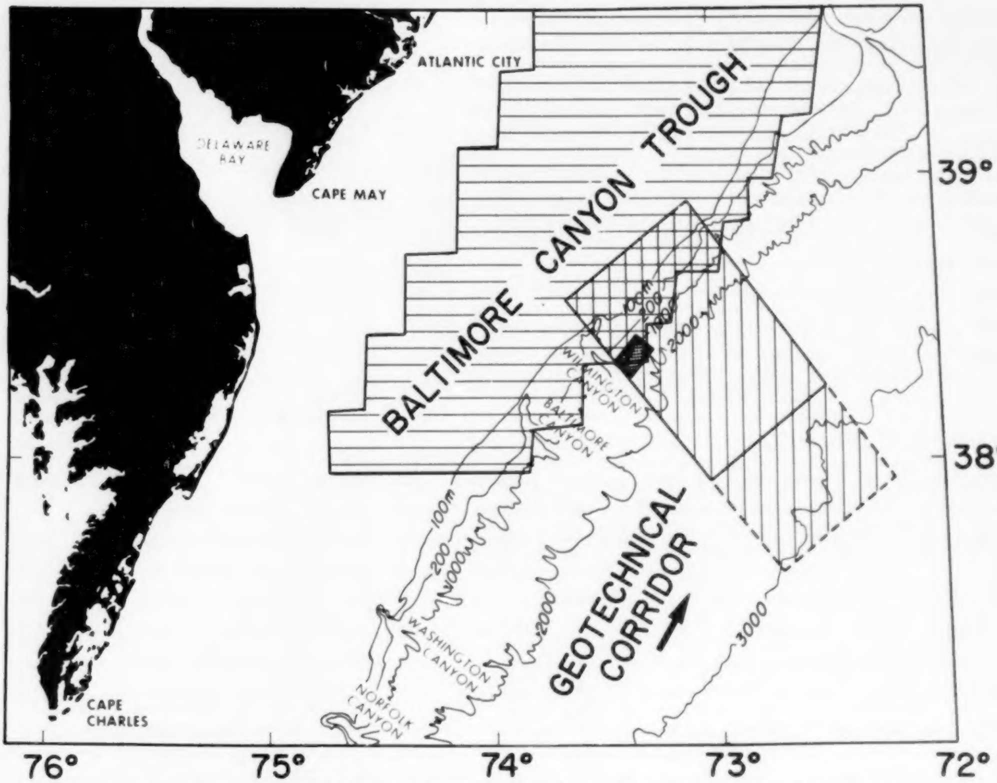

Figure 27. -- Map shows Baltimore Canyon Trough and the area of geotechnical study. Sediment slides appear still to be occurring in the dark rectangular area near the geotechnical corridor adjacent to Wilmington Canyon.

by the researchers from an area covering more than half the corridor as part of an expedition aboard the NOAA ship RESEARCHER during September 1977.

The oceanographers returned to the region last summer to sample, in detail, different types of sediment deposits which have moved to determine their geotechnical properties and how recently the movements may have taken place.

Results of the two expeditions indicate that extensive sediment movement has occurred on the continental slope and rise seaward of the Baltimore Canyon Trough. Horizontally moving blocks of sediment ; circular, arc-type rotating blocks; and thin-debris flow slide masses which are known to characterize sediment instability were all found in the region.

"From the geophysical data we can see that sediment failure has been very important in shaping seafloor form and structure and in controlling sediment thickness on the continental slope and rise. Sediment instability initially identified on the upper slope has been found to be widespread on the lower slope and rise in the area," reported the oceanographers.

A detailed, full-color bathymetric and slope map of a major submarine slide in a selected area of the geotechnical corridor is available from the Marine Geology and Geophysics Laboratory, AOML/NOAA, 15 Rickenbacker Causeway, Virginia Key, Miami, FL 33149.

TWO RETIRE FROM PMO OFFICE IN OAKLAND

William J. Hocking of the Marine Observation Office in Oakland, Calif., retired in July 1978 after 37 yr with the National Weather Service in the San Francisco area. He was coordinator of the Cooperative Ship Observing Program for the Weather Service. He joined what was then the Weather Bureau in 1941 at San Francisco. In 1947 he was assigned to the Weather Records Processing Center, and in 1962 he joined the Pacific Weather Project. From that time until his retirement he was involved with marine weather and the Cooperative Ship Program.

Marvin H. Hofer, Port Meteorological Officer for the Oakland-San Francisco area, retired in September 1978 after 35 yr of Federal service. He was born in Illinois in 1923. During World War II he served in the U.S. Navy as an aerographer's mate. He joined the Weather Bureau in 1946 in San Francisco and remained in that area until his retirement. He was named the PMO for San Francisco in 1975.

Mr. Hofer died on November 11, 1978, after enjoying only about 2 mo of his retirement.

ICE DATA FOR ALASKA

Ice information has always been important to shipping in Alaska. A table of ice breakup and freezeup dates for Alaska has been updated by Dick DeAngelis

Table 4.--Ice breakup and freezeup in Alaska

STATION	WATERS	ICE BREAKUP				ICE FREEZEUP			AVG. YEARS RECORD	PERIOD
		Average	Earliest	Latest	Shipping	Average	Earliest	Latest		
Talkeetna	Susitna River	May 7	4/9/65	5/25/52		Dec. 5	11/9/63	1/3/60	18	1919 - 1971
Anchorage	Lake Spenard	Apr. 11	2/16/44	5/23/71		Oct. 28	10/9/65	12/10/36	30	1915 - 1971
King Salmon	Nankek River	Apr. 15	2/28/60	6/1/64	May 1	Nov. 28	10/17/39	12/22/57	20	1916 - 1971
Platinum	Goodnews Bay	May 6	3/30/57	6/6/64		Nov. 23	10/23/30	12/12/47	20	1928 - 1965
Bethel	Kuskokwim River	May 16	4/24/40	6/8/64	May 23	Nov. 2	10/8/28	11/24/51	43	1923 - 1971
Crooked Creek	Kuskokwim River	May 8	4/22/40	6/3/64	May 14	Nov. 13	11/1/64	12/2/52	23	1937 — 1971
McGrath	Kuskokwim River	May 10	4/24/40	5/30/64	May 6	Nov. 5	10/13/58	11/15/52	27	1939 - 1971
Nunivak	Mekoryuk River	May 21	4/18/50	6/13/60		Nov. 29	11/20/56	12/13/47	11	1943 - 1969
Gambell	Lake Troutman	June 1	5/1/43	7/1/50		Nov. 3	10/15/49	12/14/40	14	1940 - 1970
Unalakleet	Unalakleet River	May 20	4/28/40	6/12/64	May 23	Oct 12	10/8/39	11/19/37	25	1937 - 1970
Moses Pt.	Kwiniuk River	May 28	5/2/51	6/15/66	May 31	Oct. 22	10/1/51	11/2/52	17	1943 - 1969
Nome	Norton Sound	May 30	4/28/42	6/28/48	June 3	Nov. 12	10/13/18	12/13/47	60	1900 - 1971
Teller	Grantley Harbor	June 7	5/12/36	6/19/62		Nov. 12	10/13/42	12/26/50	23	1936 - 1967
Russian Mission	Yukon River	May 17	4/25/40	5/31/71	May 19	Nov. 10	10/21/28	12/2/67	15	1928 - 1971
Holy Cross	Yukon River	May 18	4/25/40	5/30/71	May 26	Oct. 30	10/12/31	11/30/34	42	1917 - 1971
Galena	Yukon River	May 20	5/8/51	6/9/64	May 28	Nov. 4	10/11/47	12/8/50	21	1943 - 1968
Tanana	Yukon River	May 15	4/29/40	5/28/65	May 17	Nov. 5	10/13/30	11/22/37	45	1917 - 1971
Fort Yukon	Yukon River	May 15	5/5/60	5/27/71	May 19	Oct. 28	10/14/41	11/15/52	40	1918 - 1971
Eagle	Yukon River	May 10	4/25/40	5/20/63		Nov. 16	10/18/30	12/15/68	41	1917 - 1971
Wales	Bering Strait	June 11	5/15/47	7/1/67		Dec. 4	10/8/48	1/8/51	21	1927 - 1971
Kotzebue	Kotzebue Sound	June 6	5/17/40	7/27/64	June 14	Oct. 6	10/2/39	11/8/54	29	1929 - 1971
Selawik	Selawik River	May 29	5/13/40	6/8/64	May 24	Oct. 16	10/3/46	10/30/38	20	1927 - 1971
Kobuk	Kobuk River	May 20	4/30/53	6/7/64	May 24	Oct. 19	10/3/71	11/2/38	24	1937 - 1971
Wainwright	Arctic Ocean	July 6	6/7/44	8/1/67		Oct. 5	9/26/58	10/27/66	15	1939 - 1967
Point Barrow	Arctic Ocean	July 22	6/6/57	8/22/31		Oct. 25	8/31/27	12/19/47	36	1920 - 1971

Freezeup dates indicate dates safe for man.
Breakupdates indicate dates of last ice.
Shipping is average date ice permitted shipping.

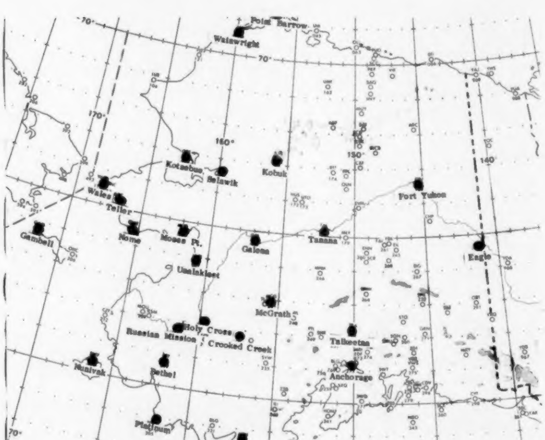

Figure 28.--Location of Alaskan ice-reporting stations.

of the Environmental Data and Information Service (table 4). It contains averages and extremes for numerous locations (fig. 28). The table originally appeared in the North Pacific Climatological and Oceanographic Atlas for Mariners and in U.S. Coast Pilot No. 9. It had not been revised since 1952. These data were gathered annually by the State Climatologist for Alaska and published in either the June or July issue of the Climatological Data for Alaska. This collection stopped in 1971.

CHANGE OF ADDRESS FOR MIAMI PMO

The Port Meteorological Officer in Miami, Fla., has moved to Dodge Island at the Port of Miami. His new address and telephone number are:

Walter Sitarz
Port Meteorological Officer
National Weather Service, NOAA
1600 Port Boulevard
Miami, FL 33132
Telephone: 305-358-6027

Figure 29.--Captain Knowlton (right) is presented his Public Service Award by New York PMO Charlie Schlott.

PUBLIC SERVICE AWARD

Captain James A. F. Knowlton (fig. 29) of the United States Lines AMERICAN APOLLO was presented a Public Service Award by the National Weather Service. He is retiring after 41 yr maritime service. A faithful weather reporter, the AMERICAN APOLLO has been in the cooperative ship program since 1970.

Captain Knowlton first went to sea in 1925. In 1936 he joined the United States Lines aboard the WASHINGTON, and later sailed the VIRGINIA, MANHATTAN, and JOHN ERICSON. During World War II he commanded the USS LUNA. As Second Officer of the AMERICAN FARMER in 1928, he commanded a lifeboat which rescued seven men from the foundering three-masted schooner FIELDWOOD. For this he received the Distinguished Service Medal from United States Lines and a Silver Medal from the Lifesaving Benevolent Association of New York. During 1950 Captain Knowlton's ship the PIONEER DALE was bombed and strafed off the China coast.

SATELLITE LASER TO MEASURE GLOBAL WINDS

A laser radar (or "lidar") installed aboard a satellite 500 mi above the Earth's surface would be able to measure winds in the atmosphere around the globe, according to NOAA scientists who hope to have such an instrument ready for feasibility testing aboard the Space Shuttle in 1984.

The lidar, the scientists reported at a recent meeting of the Optical Society of America in San Francisco, would increase the utility of present environmental satellites and could help improve weather predictions. Instruments aboard current satellites like NOAA's polar-orbiting and geostationary spacecraft allow wind velocity analysis to be done, but only where clouds are available.

A study indicates that a carbon dioxide laser-powered lidar, or optical radar, could measure windspeed with an accuracy of 1 m/s and wind direction to within 10 degrees. The lidar measurements also would provide valuable information on the depth of the planetary boundary layer and the intensity of atmospheric turbulence, neither of which is now available from satellite instruments.

An operational lidar installed on a polar-orbiting satellite would provide information on windspeed and direction at evenly spaced locations about 185 mi apart covering the entire globe every 12 hr. Two satellites could provide global coverage every 6 hr.

To measure the winds, the frequency-controlled laser would send a stream of very concentrated light through an intricate system of lenses and mirrors beamed obliquely at the Earth beneath the satellite. When the beam of light irradiated naturally occurring aerosols, such as dust particles or droplets in the atmosphere, a portion of this light energy would be scattered back to the satellite-borne instrument. The motion of the windborne aerosols would cause a Doppler frequency shift in the return. By measuring the amount of this frequency shift, it is possible to calculate the windspeed and direction.

DIFFICULT UPRIVER TOW OF PORTLAND DRYDOCK

A new drydock was delivered successfully to the Port of Portland last September after a long voyage from Japan. How the giant vessel made the last 100 mi of its voyage and the planning that went into it is interesting. The responsibility went to Willamette Tug and Barge Company.

After a 5,200-mi journey across the Pacific Ocean from Japan, where the $17.5 million drydock was constructed, the huge structure was met by four tugs in Astoria harbor for the final leg of the tow up the Willamette and Columbia Rivers. The giant tugs are capable of churning out over 10,600 hp.

For the tow up the Colur bia, two tugs generating 6,600 hp pushed at the drydock's stern, and one 2,000-hp tug towed on a towline. The fourth tug, also generating 2,000 hp, remained free for use by the pilots as required.

The biggest of the four tugs, the 110-ft-long WILLAMETTE PILOT, is the largest and most powerful ship operating in the Columbia and Willamette Rivers. It was purchased for $2.2 million after a Port of Portland study indicated such a vessel was needed in the harbor.

Engineers worked for months to prepare a complete "Towing and Operating Procedure Guide" for the intricate towing operation. This report was approved by the manufacturer, the U.S. Coast Guard, Willamette River Pilots, and other interested parties.

To prepare the Guide the engineers carefully studied every navigation hazard on both rivers and conducted a mile-by-mile analysis of the rivers, covering every possible contingency including fog, wind, tides, and other sudden unfavorable weather and river conditions.

Potential problem areas on the Columbia included Pillar Rock, Skamokawa Bend, Eureka Sands, Stella, Coffin Rock, St. Helens-Warrior Rock, and the entrance to the Willamette River. The Guide also pinpointed 11 separate areas along the Columbia and Willamette for anchorage, dockage, or beaching in case of emergency.

The single most-difficult challenge of the tow was on the Willamette River, where the drydock had to pass through the Burlington Northern Railroad bridge drawspan.

First, Willamette engineers had to determine the exact width of the drawspan opening, which had been listed at 230 ft for years by Coast and Geodetic Charts. The design width of the drydock was 228 ft plus a 16-in

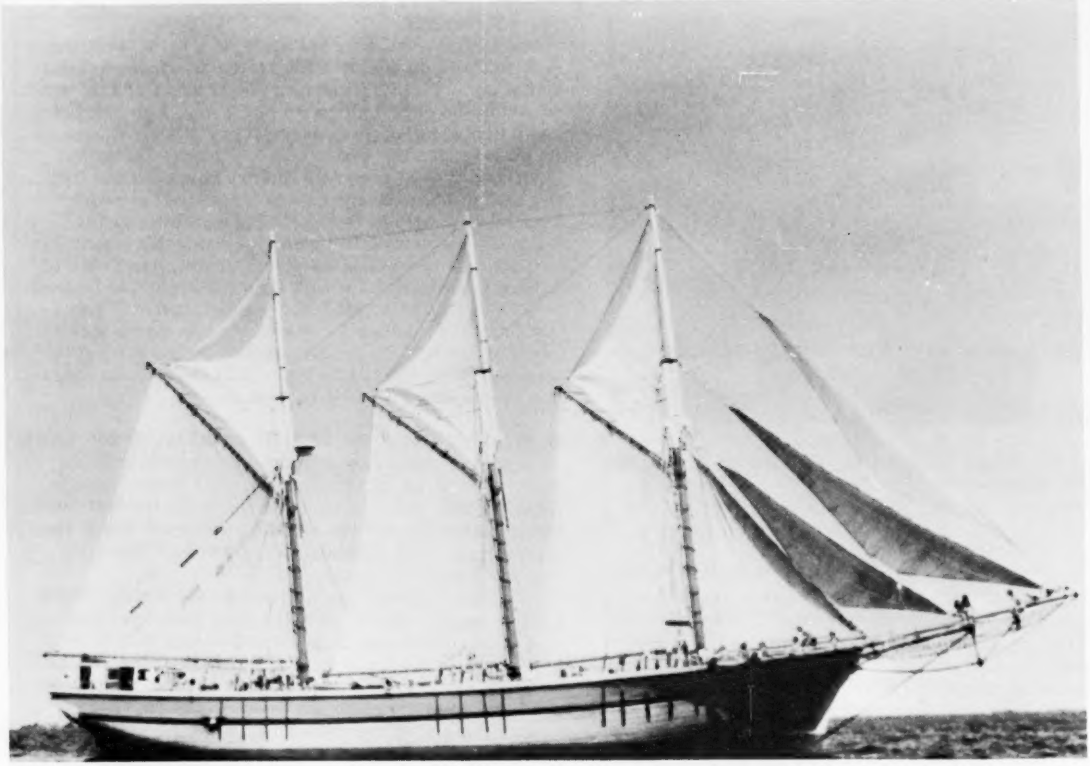

Figure 30.--The 100-ft long wooden cargo schooner BERTA OF IBIZA under full sail. Could this be the start of a new trend? Photo courtesy of Shilon Navigation.

mooring guide and a 1/2-in doubler plate, for an overall width of 229 ft, 4-1/4 in.

However, through the years the bridge's drawrest protection had been rebuilt and repaired a number of times, and it was therefore unknown what the precise present opening actually was. So the engineers physically measured the opening and found it to be exactly 231 ft, 6 in. There was sufficient clearance to pass the drydock through the opening.

In order to safely transit the bridge and protect the drawspan during the drydock tow, the engineers had developed a comprehensive program. Guide dolphins plus necessary replanking were placed at each end of the drawspan, and the drawrest was sheeted with a 4-ft-high band of plywood for the drydock to move against as it came through the opening. The drydock was brought up to the downstream end of the bridge, stopped, and brought to rest against a 17-pile guide dolphin with the port side to the dolphin. When all tugs and a bridge tender were ready, the drydock was slowly slid along the dolphin and the specially prepared drawrest, keeping the port side flat on the drawrest. The bridge operator swung the span away from the drydock on approach, back to parallel as the drydock went through, and again away as the drydock exited.

After the difficult transit of the bridge, the drydock was moved upriver to its destination at Terminal No. 1 near Swan Island.

SAILING SHIP CARRIES CARGO TO TRINIDAD

For the first time in 42 yr and possibly for the last, a sailing ship left the Port of New York carrying a commercial cargo on November 20, 1978.

The BERTA OF IBIZA, a 100-ft long, three-masted schooner (fig. 30), was chartered by Chesebrough-Pond Inc. to haul 60,000 lb of raw materials and finished products to its plant in Port of Spain, Trinidad.

Despite the nostalgic nature of the voyage, the charter is a valid commercial shipment, according to the freight forwarder, Export-Import Services Inc. of New York.

Trinidad's deep-water facilities were heavily damaged by a recent fire, almost completely closing conventional sea transport, and the island's air freight facilities have not been able to handle the resulting increase in air cargo. The BERTA, when she reaches the Port of Spain, will be tied up at one of the shallow-water piers that escaped damage in the fire. Her cargo will be unloaded by hand since the port's cranes are also unavailable.

STUDY OF SHIP MANEUVERING ON LAKES, SEAWAY

The U.S. Maritime Administration has awarded a 2-yr $342,000 grant to Stevens Institute of Technology's Davidson Laboratory for the study of ship-maneuvering characteristics in Great Lakes and St. Lawrence Seaway channels.

The project will use both digital computer simulations of problem conditions now existing and the ice model basin of Arctec Inc. in Columbia, Md., for investigating maneuvering in normal and iced conditions.

After analyzing the results, the laboratory will formulate guidelines for channel and vessel size, required ship-maneuvering characteristics, and operating procedures under increased traffic conditions. It will also develop criteria for determining which vessels can safely and effectively navigate the system during the winter.

SEAWAY AND WELLAND CLOSE

The 1978 shipping season on the St. Lawrence Seaway closed on December 21, 1978. The HAND FORTUNE was the last saltie to pass through the U.S. Snell and Eisenhower Locks. There was some debate on whether the ship would be allowed to transit downbound because it had violated Seaway closing procedures by entering the Upper Lakes after the cutoff date. The last lakers to transit the Seaway were the J.N. MCWATERS downbound and the SILVER ISLE upbound. The Welland Canal closed on December 30 as scheduled with the passage of the NIPICONE BAY downbound and the HOCKELAGA upbound.

LETTERS TO THE EDITOR

S.S. MAYAGUEZ

I wish to thank Captain Stanley Malewski for two interesting letters. The first (fig. 31) concerns the rescue of 15 crewmen from the sinking fishing boat LOONG HSIANG No. 11, and the second is a record of the hourly weather (fig. 32) and the barograph (fig. 33), while the MAYAGUEZ was anchored in Manila Bay as typhoon Rita passed 60 mi to the north.

1425 MARITIME STREET, OAKLAND, CALIFORNIA 94607 — PHONE: (415) 835-8340

SEA-LAND SERVICE, INC.

S.S. Mayaguez
Kaohsiung, Taiwan
October 24, 1978

Mariner Weather Log
US Dept of Commerce
National Oceanic & Atmospheric Adm.
Environmental Data Service
Washington D.C. 20235

Attn: Elwyn E. Wilson, Editor

Re: Rescue 15 Taiwanese Fishermen sinking fishing boat Loong Hsiang #11

Dear Mr. Wilson:

On October 9, 1978, 1458 hours, enroute from Manila, P.I. to Kaohsiung, Taiwan, Lat. 20-52 N., Lo. 119-57 E. a fishing boat was sighted displaying distress signals.

The Loong Hsiang #11, a 114-ton seiner fishing boat was sinking. Vessel maneuvered alongside sinking fishing boat. The entire 15-man crew was rescued. No injuries. Fishing craft abandoned as sinking derelict. Survivors were taken to Kaohsiung.

Wind NE Force 7 - Very rough NE Sea & Swell.

Stanley Malewski
Stanley Malewski, Master

encl.
cc: ship's file

S.S. MAYAGUEZ
OFF No. 245546

Figure 31.-- Letter from Captain Malewski.

S.S. Mayaguez Voyage 406
Kaohsiung, Taiwan
October 31, 1978

Mariner Weather Log
US Dept. of Commerce
National Oceanic & Atmospheric Adm.
Environmental Data Service
Washington D.C. 20235
Attn: Elwyn E. Wilson, Editor

Re: Typhoon Rita passing Manila October 27, 1978

This vessel was anchored in the middle of Manila Bay during this typhoon Rita. Lat. 14-36 N., Lo. 120-47 E.

For your information, the weather data from our deck log and the baragraph chart are enclosed.

Very truly yours,

Stanley Malewski
Stanley Malewski, Master

26 October 1978 ZD -8

LOCAL TIME	SKY	WIND DIRECTION	FORCE	VISIBILITY	BAROMETER	TEMP. AIR
0200	CLEAR	NNW	2	98	29.77	80/77
0400	CLEAR	NNW	2	98	29.62	80/78
0600	PT. CLOUDY	NXW	3-4	98	29.64	79/76
0800	O'CAST LT RAIN	NE	4	96-97	29.72	78/75
1000	LT RAIN CLOUDY	NE	3	97	29.67	82/77
1200	O'CAST	WXN	3	97	29.59	84/78
1400	O'CAST	NXW	2	97	29.51	86/78
1600	O'CAST	LT AIRS		96	29.48	83/79
1800	SQUALLS CLOUDY	NW	4	98	29.42	83/77
2000	SQUALLS CLOUDY	NW	5	97	29.40	83/76
2200	O'CAST LT. RAIN	NW	6-7	98	29.32	84/78
2400	O'CAST LT. RAIN	WNW	8	98	29.23	83/78
	27 October 1978					
0200	HEAVY RAIN	SW	9	94	29.20	80/79
0300	HEAVY RAIN	SW	9	91	29.27	
0400	HEAVY RAIN	SSW	9	92	29.32	
0600	STEADY RAIN	SW	8	94-95	29.42	
0700	STEADY RAIN	SSW	8	95	29.48	
0800	LT. RAIN	S'LY	7-8	95-96	29.51	78/76
0900	O'CAST LT RAIN	S'LY	5-6	95	29.54	
1000	LT RAIN	SXE	4-5	96	29.60	
1200	O'CAST LT. RAIN	SSE	4	96	29.60	
1400	LT.-HEAVY RAIN	SE	5	95	29.58	
1600	O'CAST-LT. RAIN	SE	4	98	29.60	79/74
1800	O'CAST	SEXE	3-4	98	29.64	79/76
2000	PT. CLOUDY	SE	2-3	98	29.68	78/77
2200	PT. CLOUDY	SE	2	99	29.70	80/78
2400	PT. CLOUDY	SE	2	99	29.70	80/78

Typhoon Rita passed about 60 miles north of Manila, P.I.

S.S. MAYAGUEZ
OFF. NO. 245546
SEA-LAND SERVICE, INC.

Figure 32.--Hourly weather, typhoon Rita, Manila Bay.

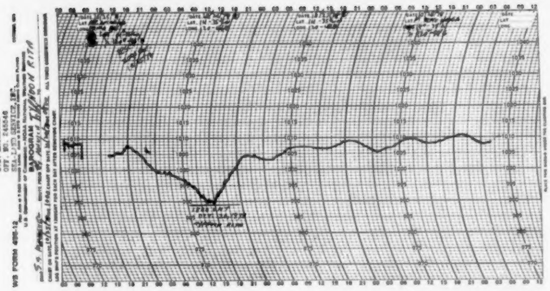

Figure 33.--Barogram of the MAYAGUEZ during the passage of typhoon Rita.

PUBLICATIONS OF INTEREST TO MARINERS

HISTORY OF NORTH ATLANTIC TROPICAL CYCLONES

The National Weather Service and the Environmental Data and Information Service have just published a new edition of Tropical Cyclones of the North Atlantic Ocean, 1871-1977. This is an update of similar tropical-cyclone publications. The latest was Weather Bureau Technical Paper No. 55. The new publication presents statistical summaries and the tracks of tropical cyclones by year, month, and 10-day period. It can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. The stock number is 003-017-00425-2; the cost is $3.50.

MARINE WEATHER REVIEW

The SMOOTH LOG (complete with cyclone tracks [figs. 38-41], climatological data from U.S. Ocean Buoys [table 5], and gale and wave tables 6 and 7), is a definitive report on average monthly weather systems, the primary storms which affected marine areas, and late-reported ship casualties for 2 mo. The ROUGH LOG is a preliminary account of the weather for 2 more recent months, prepared as soon as the necessary meteorological analyses and other data become available. For both the SMOOTH and ROUGH LOGS, storms are discussed during the month in which they first developed. Unless stated otherwise, all winds are sustained winds and not wind gusts.

Smooth Log, North Atlantic Weather

July and August 1978

SMOOTH LOG, JULY 1978--The majority of the low-pressure centers occurred over Canada. A mean track would extend from northwest of Lake Winnipeg to south of James Bay to Labrador and then northward toward Baffin Bay. Two storms tracked northeastward off the east coast of the United States to join the path of the few storms that continued eastward out of Canada. This path continued eastward, then turned

northeastward south of Iceland, and ended over the Norwegian Sea. During the second week of the month one LOW abruptly turned southward, and during the fourth week another turned northward near the same position south of Iceland. No storms penetrated the European continent south of 55°N. The storms basically followed the climatic pattern, except climatology indicates more storms off the North American east coast and more continuing eastward from Canada.

The mean pressure pattern south of latitude 55°N was very near the climatological normal. The primary feature was the Bermuda-Azores High. At 1026 mb it was normally located near 33°N, 39°W. There was an anomalous subcenter off the coast of Portugal. The usual HIGH over the Greenland icecap slipped southward off Angmagssalik. The LOW usually over Iceland was displaced to near the Faeroe Islands. The primary LOW, which is normally over Cape Chidley, was displaced to the Foxe Channel north of Hudson Bay.

The largest departure from normal was a positive 6 mb associated with the Greenland High. The largest negative anomaly was 3 mb centered with the Foxe Channel Low.

The upper air differed significantly from climatology over the area north of latitude 55°N. The normal trough that usually extends from the North Pole southward along the eastern North American coast was replaced by a deep closed LOW at 700 mb. It was centered near Repulse Bay of northern Canada. The circulation around this LOW brought a sharp ridge northward over Greenland. A second anomalous LOW was situated over the Norwegian Sea. The High along latitude 30°N over the central ocean was slightly lower than normal.

The LOW and ridge over the northern areas produced large anomaly centers of opposite polarities over northeastern Canada and Greenland.

Tropical storm Amelia developed over the western Gulf of Mexico on the last day of the month.

Extratropical Cyclones--This storm moved out of the northern plains on July 1. It crossed the coastline near Delaware Bay on the 4th, bringing heavy rains to that area. The SISAK was several hundred miles off Cape Hatteras south of the front and reported 53-kn southwesterly winds. At 1200 on the 5th the 1000-mb LOW was near 40°N, 67°W. At that time the BEN OCEAN LANCER was northeast of the center near 43°N, 62°W, with 45-kn easterly winds. The EXPORT FREEDOM found 40-kn winds from the south and 13-ft waves near 39°N, 51°W. On the 6th the winds were still 40 kn out of the south near 39°N, 55°W, but the swell waves had grown to 15 ft. The storm was northeast of St. John's on the 7th, and the PERSEY had northerly 47-kn winds near 50°N, 50°W. At 1800 the German ship DIMC at 49.4°N, 40°W, radioed a report of 52-kn winds out of the southwest driving 33-ft seas. As she sailed on a southwestward course on the 8th, the winds dropped to 40 kn and the seas to 28 ft. Later that day the CITY OF GUILDFORD was east of the 986-mb center with 37-kn winds and swells to 23 ft. OWS Charlie measured 39 kn and 13-ft seas.

On the 10th the LOW abruptly turned southward as a HIGH aloft drifted southward from the Norwegian Sea to southwest of the Faeroe Islands. The LOW, which at this time could not be considered a significant storm, continued a jagged southerly track until the 15th, when it was centered over the Azores. On the 14th a ship reported 35-kn winds and 20-ft seas in the western quadrant. After midday on the 15th, the LOW swung northward for 24 hr, then eastward to dissipate over the Bay of Biscay on the 18th. This was an exceptional storm in that it survived as an entity for 18 days.

The ROBERTS BANK was sailing northward off the coasts of Morocco and Portugal from the 5th to the 8th. A low-pressure area was stationary over Scandinavia. On the 5th there was a north-south elongated high-pressure area, west of the European coast, centered over 50°N, 25°W. There was also low pressure over the desert of central Algeria. This produced a tight gradient with northerly winds from Iceland to south of the Canary Islands. On the 5th the BANK was near the Canary Islands and measured 40-kn gales. The winds remained in the gale category as she sailed northward to near Porto on the 8th. The seas during this time were running 5 to 10 ft. During this time period, the HIGH drifted southward and bulged to the east over the Bay of Biscay, lessening the pressure gradient as the ship approached its center.

This LOW was first analyzed on the 0000 chart of the 17th over the entrance to the Chesapeake Bay. On the 18th the 1005-mb LOW was over Newfoundland with a trough extending eastward into the Azores High. The ROMAN PAZINSKI was north of the trough line and 600 mi east of the LOW with 43-kn south-southeasterly winds. The pressure dropped to 994 mb at 1200 on the 20th near 56°N, 36°W. A SHIP reported 41-kn southerly winds about 300 mi southeast of the center at 0600. At 0600 on the 21st the C. P. TRADER was near 54°N, 37°W, with 37-kn northwesterly winds, 13-ft seas, and 23-ft swells 30 degrees off the seas.

On the 22d the 988-mb LOW was south of Iceland at latitude 58°N. The ANNA JOHANNE was at latitude 60°N with 44-kn northeasterly winds and 21-ft seas. At 1200 OWS Romeo measured 35-kn gales and 20-ft seas. Near the storm's center four ships reported winds of 45 kn from the northeast with the highest seas being 21 ft. Ocean Weather Station Lima measured 40-kn winds on the 23d after the storm passed almost directly over her position. At this time the LOW turned northward and moved into the Norwegian Sea where it died on the 26th.

This frontal wave developed over the Midwest and raced eastward over the Great Lakes to the Maritime Provinces of Canada on the 24th. It was associated with a fast-moving short wave in the upper air. At 1200 on the 25th the surface LOW was 998 mb near 47°N, 42°W. The HANS SACHS (43°N, 49°W) had 35-kn winds on her starboard bow. By the 26th an upper air LOW had developed, and the storm slowed in its race eastward. Six ships in the southern half of the circulation reported 35- to 40-kn winds with the highest seas and swells reported at 16 ft. On the 27th the LOW was absorbed by another over Iceland.

On July 31 an east-west-oriented front extended across the Norfolk, Va., area. Weak frontal waves were moving along the front triggering thunderstorms, especially south of the front. A waterspout developed

with one of these severe thunderstorms and struck Kill Devil Hills on the North Carolina Capes. One person was known dead, and several others were missing as a result.

Tropical Cyclones--Up until the end of July it had been a typical Texas summer--hot and dry. High temperatures and lack of moisture were causing cotten balls to open, pecan nutlets to drop, and peaches to ripen slowly. Range and pasture lands were deteriorating, range fires were a problem, and stock water supplies were drying up. Then along came Amelia--and all of a sudden Texas had too much water.

Amelia popped up close to the Mexican coast about 30 mi south of Brownsville, Tex., early on the 30th. She moved north-northwestward, and she intensified. Maximum winds reached 45 kn before Amelia crossed the coast just north of Brownsville during the night of the 30th. These winds were enough to cause tides 2 to 4 ft above normal and to cause some damage to shipping. At least five shrimpboats were missing, and the 34-ft pleasure boat MISS LAURIE ANN was wrecked. But Amelia's real threat were her rains.

It began slowly at first--the normal showers and thunderstorms expected with a weakening tropical storm as she moves overland. By the 1st several places had recorded more than 5 in and a few more than 6 in. Flash flood warnings were up for southern Texas. The next night thunderstorms dumped heavy rains at the head of the Guadalupe, Medina, and Sabinal Rivers. Vanderpool reported 11 in, and there were amatuer radio reports of up to 20 in over the hill country northwest of San Antonio. The ill-defined remains of Amelia continued to move slowly northward. And the rains spread westward and northward. The resultant flooding was widespread and devastating. Record rises along the Guadalupe include a 1-ft rise in 20 min at Kerrville, where 22 in of rain had fallen. The river rose several inches above the bridge of Highway 281--the bridge is 59 ft high. Several other rivers and streams reached record crests, and by late on the 2d rains had spread to Roswell, N.M. By Friday the 4th 9 to 11 in of rain had fallen over northern central Texas. In the Abilene area 18 in were recorded at Stamford and 14 in at Albany. Record flood stages occurred on the Brazos River at Ft. Griffin, where reports of up to 30 in of rainfall were received.

Casualties--The fishing vessel CAPTAIN GIBBY that sank during a squall at Empire, La., on June 30 was raised on July 2 and sent to the repair yard. The 10,506-ton PHOTINIA, which went aground in Lake Michigan owing to high winds and waves during May, was refloated on July 7 with the assistance of 7 tugs. The dredging barge PENNSYLVANIA foundered in rough seas in Rockaway Inlet while under tow on the 31st. Swells of 3 to 5 ft hindered the containment and control of No. 2 and No. 6 oil, which was leaking from the barge.

The 694-ton Lebanese freighter SAAD sank after a collision with the 4,389-ton Greek-registered WALTER in fog near 50°N, 01.2°W.

SMOOTH LOG, AUGUST 1978--The primary concentration of low-pressure centers was along a path from west of Lake Winnipeg to Labrador and then across Iceland. A secondary path branched northeastward over the province of Quebec to the Labrador Sea. A climatological track along the St. Lawrence River valley did not exist. One storm center traveled southeastward across the Great Lakes, moved northeastward off the East Coast, and ended over the Denmark Strait. Two storms turned southward when east of Newfoundland.

As is expected during a summer month, the primary feature over the ocean was high pressure. The Bermuda-Azores High was 1024 mb near 30°N, 38°W. This was only 1 mb higher and 300 mi south of its climatic pressure and position. A significant feature was a ridge of higher than normal pressure--about 4 mb--that projected northeastward to the English Channel. A 1007-mb LOW was near Lake Harbour on the Hudson Strait, while the primary 1005-mb LOW was shifted northward, north of Ellesmere Island.

The two primary anomaly centers that influenced marine weather were both positive. One was 6 mb and centered off Ireland in connection with the higher pressure of the aforementioned ridge. The other was a larger, less intense area of 3 mb that stretched from Florida to Newfoundland. The displacement of the primary LOW resulted in a minus 7-mb anomaly west of Ellesmere Island. The two storms that traveled southward over the ocean resulted in a minus 2-mb anomaly center over the central area--42°N, 35°W.

The mean 700-mb surface was radically different in pattern from climatology. Zonal flow stretched from the west coast of North America to midocean near 40°W before turning northeastward to form a slight ridge over the east coast of Europe. There are normally troughs along the North American east coast and European west coast.

There were four tropical cyclones this month. They were tropical storms Bess and Debra and hurricanes Cora and Ella.

Extratropical Cyclones--As the month began a LOW was passing over Kap Farvel. The usual front was wrapped around its east side and trailing more toward the south than west, breaking the HIGH into two centers. On the 2d the northern center moved rapidly eastward following the front. By 1200 of the 3d the chart showed that a 1016-mb frontal wave had developed near 46°N, 42°W. The center moved southward and the circulation enlarged. At 1800 on the 4th the WORTH (38°N, 40°W) was 250 mi southwest of the center with 45-kn westerly winds in showers. Her report also indicated 33-ft swells. At 0000 on the 5th the BOOKER VANGUARD was very close to the same spot with lightning, but the winds were only 25 kn and the swells 16 ft. The surface LOW had now built up to the 700-mb level. At midday the LUDWIGSHAFEN was north of the center with 35-kn gales from 060°.

On the 6th and 7th the LOW circled clockwise around a center near 37°N, 39°W. Late on the 7th it lost its upper air support and drifted northeastward to completely dissipate late on the 8th. The lowest pressure the storm attained was 1010 mb on the 4th.

A weak stationary front stretched east to west across the Mediterranean Sea on the 6th. A HIGH off the coast of Portugal consolidated into one center on the 0000 chart of the 7th, and by the 0600 chart a frontal

wave had formed off of Barcelona. All this tended to increase the northerly circulation, and at 1200 the coastal town of Alicante, Spain, was measuring 30-kn winds. The airport at Tripoli, Libya, had 35-kn scorching winds out of the south. At 1800 two ships in the vicinity of 32°N, 10°W, off the Moroccan coast had northerly winds between 40 and 45 kn with seas up to 13 ft. The ROUSSILLION, south of Marseille, had 45-kn winds from the northwest at 0000 on the 8th. The DOVER CASTLE was off the west coast of Corse at 1200 with 40-kn westerly winds, 13-ft seas, and 25-ft swells. At this time the 992-mb LOW was over Berlin. The storm continued northeastward and no longer affected the marine area.

Northern Italy was hit by flash floods, tornadoes, and the first August snow in half a century. In the south a hot sirocco wind fanned forest fires. Twelve bodies were found and 10 people were missing. Most of the continent had suffered a wet summer. Blizzards and other freak weather in the Swiss Alps contributed to the death of more than 30 Alpine climbers during the previous few weeks.

A storm came out of Labrador on the 6th and moved northeastward across the Labrador Sea. Another center was analyzed farther south in the trough on the 0000 chart of the 8th. At 1200 a SHIP near 45°N, 44°W, reported 50-kn winds. The BEN OCEAN LANCER was off Hamilton Inlet at 1800 with 35-kn winds and 13-ft seas and swells. The storm was tracking eastward, and the circulation was becoming better organized. At 1800 on the 9th, three ships reported high winds east of Newfoundland. The SELFOSS reported the highest of 58 kn. The SIR W. ALEXANDER was south of Halifax with 40-kn gales. On the 10th the storm was 994 mb. Two ships along longitude 42°W near latitudes 50° and 58°N had 37-kn gales. An Icelandic ship was northeast of the center on the 11th with 38-kn gales. On the 12th the center dissipated into a trough.

On the 11th the EXPORT PATRIOT was near 40°N, 58°W, at 1100, about 100 mi southeast of the cold front. She sighted waterspouts and reported them in the remarks column.

The cold front mentioned above stretched stationary east-west across the central United States. By the 14th it was no longer detectible due to frontolysis west of the Appalachian Mountains. A high-pressure cell had formed over the eastern Gulf of Mexico. There was little pressure gradient south of New Orleans as the USCGC ACUSHNET was proceeding to Buoy EB71 (42002) from Gulfport, Miss. At 1715 they sighted a waterspout and at 1745 two waterspouts. At the time they were near 28.8°N, 89.2°W.

Monster of the Month--On the 13th an east-west front crossed the U.S. Atlantic coast near Delaware Bay. A series of shallow waves were indicated on the analysis. On the 0000 chart of the 14th a 1014-mb unstable wave was analyzed near 42°N, 59°W. At 1200 the CETRA CARINA (39°N, 58°W) was south of the cold front with 40-kn southwesterly winds and heavy rain.

As the storm moved east of Newfoundland and south of Kap Farvel, it quickly intensified. At 1200 on the 15th the pressure was 993 mb, and several ships reported gales. The highest noted was 52-kn storm

winds by the SIR HUMPHREY GILBERT near Belle Isle. The highest seas for the day were 20 ft reported by the ASIA LINER near 47°N, 35°W.

At 1200 on the 16th the center of the storm passed very close to Ocean Weather Station Charlie. His pressure was 984.9 mb, while the central pressure on the analysis was estimated as 980 mb. The winds were in the 35- to 40-kn range and the seas 18 ft. The LUDWIGSHAFEN (48°N, 37°W) approximately 250 mi to the south of the center (52.5°N, 37°W) reported 45 kn and 20 ft.

The storm continued to deepen as it traveled northward. Its lowest pressure was 970 mb at 1200 on the 17th, quite low for this time of year for an extratropical storm. At 0000 the BAKKAFOS was on the western edge of the storm with 55-kn northerly winds. At 1200 a U.S.S.R. ship near 53°N, 55°W, reported 58-kn winds out of the north. OWS Charlie measured gale-force winds with 18- to 20-ft seas. The storm's cyclonic circulation dominated the sea from Newfoundland to Ireland and Iceland to latitude 40°N. From 1800 on the 17th to 1200 on the 18th Charlie measured 40- to 48-kn winds with seas peaking at 26 ft. The AYAKS (52°N, 34°W) reported 54-kn winds and 20-ft seas. Late on the 18th the ANTCHAR (55°N, 36°W) contended with 54-kn winds, 36-ft seas, and 30-ft swells. A U.S.S.R. ship and the MATKO LAGINJA both found winds of 70 kn or more from the west. Charlie was rolling with 23-ft swell waves.

By the 19th the storm was beginning to weaken as the central pressure rose. This was of little consolation to the DELTA DRECHT, which was sailing eastward along latitude 60°N with 23-ft swells pounding her starboard beam. The storm moved over Iceland on the 21st and into the Norwegian Sea. Although a weak storm, it turned northward on the 23d and ended its career over the Svalbard Islands on the 25th.

A storm that developed a day earlier over Saskatchewan, Canada, moved over Baffin Bay on the 21st. As the front moved past Kap Farvel, a LOW formed off the southeast coast of Greenland. The first chart to show this was the 0000 chart on the 22d. The LOW tracked northeastward along the Greenland coast. It turned eastward over Scoresby Sound on the 23d. At 1200 the GRONLAND, east of Kap Farvel, reported 35-kn winds. The SEMAC was at 61°N, 02°E, on the 24th with gale-force winds. Later in the day the winds had increased to 44 kn, and other ships joined in with gale reports and seas up to 13 ft.

The initial LOW deteriorated over Nordkapp on the 25th, but a new center developed over Helsinki at the

same time, continuing the northwesterly flow over the Norwegian and North Seas. At 0600 the ESSO WARWICKSHIRE was midway between the Shetland Islands and Norway with northwesterly winds of 38 kn and waves of 20 ft. At 1200 she had 48 kn. The LOW was nearly stationary over the Gulf of Finland as was a HIGH west of Scotland. This continued the northwesterly flow with winds of gale force until the 28th.

This storm can be traced to the mountains of Idaho, where it was first analyzed on the 20th. It traveled across the northern United States and southern Canada mostly as a frontal wave. As it moved over the Strait of Belle Isle on the 24th, it deepened and the closed circulation expanded rapidly. At 1200 the 997-mb LOW was near 51°N, 51°W. The FALCON was about 400 mi to the southeast near the warm front with 40-kn winds out of the south. Late in the day the storm turned northward.

On the 25th the BEN OCEAN LANCER was sailing northward from near Hamilton Inlet into the Davis Strait. At 0000 it had 41-kn northerly winds that increased to 53 kn by 1800. The waves were 15 to 18 ft. Another SHIP in the area had 48 kn, and Kap Farvel measured 40-kn winds. At 0000 on the 26th the LANCER had 50-kn winds with waves building to 21 ft. On the 27th the LOW stalled near Cape Chidley.

Tropical Cyclones--Tropical storm Bess developed on the 6th in the western Gulf of Mexico, some 250 mi east-northeast of Tampico. This short-lived storm headed west-southwestward and intensified. Winds near her center climbed to 45 kn, with gales extending out 100 mi to the east and a short distance to the west. As Bess moved to within 60 mi of Tampico on the 7th, she turned toward the south. The following day she moved ashore south-southeast of Tuxpan. Later in the day the remnants of the storm dissipated over the mountains of eastern Mexico between Tuxpan and Vera Cruz.

While Bess was crashing the Mexican coast, Cora was organizing west of the Cape Verde Islands. She began as a disturbance off the northwest African coast. On the 7th she organized into the third depression of the season. The following day she was christened tropical storm Cora, and by that afternoon she reached hurricane intensity. Cora was moving westward at about 20 kn. By the 9th, while still east of the Lesser Antilles, the circulation of Cora became disorganized and her eye was no longer evident. The first reconnaissance flight, which took place that afternoon, reported 1008-mb pressure and sustained 55-kn winds in squalls. Cora was dissipating as fast as she had intensified. On the 10th she moved through the Windward Islands bringing 40-kn plus winds to St. Lucia and Barbados. The following day Cora lost all evidence of circulation and was downgraded to a tropical wave. During her brief tenure as a hurricane, satellite photographs indicated a 980-mb pressure and maximum winds of 75 to 80 kn early on the 9th.

Debra was spotted as a tropical depression in the northwestern Gulf of Mexico late in the month. She reached tropical storm strength on the 28th about 100 mi south of Port Arthur, Tex. This was confirmed by the TRANSPANAMA and the ATLANTIC HERITAGE, when they encountered 37- to 40-kn winds in 13-ft seas; the former was within 90 mi of the center at 1800 on the 28th. The EXXON NEWARK ran into 38-kn winds 6 hr later near 27.3°N, 91.5°W. Highest sustained winds near Debra's center were estimated at 48 kn as she moved ashore near the Texas-Louisiana border during the evening of the 28th. At 1500 the SAN MARCOS (28.1°N, 92.5°W) had reported 45-kn winds with 12-ft seas and 23-ft swells. The slow-moving storm dumped heavy rain totalling up to 7 in on southern Louisiana. Even though Debra weakened rapidly, her remnants produced tornadoes and heavy rains through the Delta States to northern Arkansas and extreme western Tennessee. At least eight tornadoes were sighted in Mississippi, and a late-evening twister struck Memphis.

While Debra was dying in the south, Ella was coming to life south of Bermuda. By the 30th Ella reached tropical storm strength some 300 mi south of Bermuda. She was heading west-northwestward toward the U.S. East Coast about the time that thousands of vacationers were getting ready for a last summer fling at the seashores over Labor Day weekend. The stage was set for a potential disaster -- the U.S. East Coast had gone 18 yr without a devastating hurricane. Ella reached hurricane intensity on the 31st. During the day winds continued to strengthen. By evening winds were up to 80 kn, and Ella was some 525 mi southeast of Cape Hatteras. On Friday morning (September 1) a hurricane watch was posted along the vulnerable, soon to be crowded, Outer Banks of North Carolina. Tension was mounting along the entire northeast and mid-Atlantic coast. By noon Ella crept to within 325 mi east-southeast of Cape Hatteras. Maximum sustained winds near her center climbed to near 90 kn. One good sign was a slowing of her forward speed--often an indication of turning. As traffic poured into the resorts, Ella paused about 315 mi southeast of Hatteras on Friday evening. Her central pressure was down to 960 mb, while 90-kn winds remained close to her eye. By midnight winds reached 105 kn, but it was obvious that Ella would recurve toward the north and then northeast on Saturday. During the morning Ella stalled and remained in the same area for most of the day--about 300 mi southeast of Hatteras. Finally, about midnight the watch was lifted as Ella began to accelerate northeastward. She had weakened some, but maximum winds were around 75 kn. Ella paralleled the East Coast as she moved northeastward at about 15 to 20 kn. Winds climbed to 100 kn as she reintensified on the 3d. Her forward speed jumped to 35 kn.

By the 4th Ella was threatening Newfoundland. Her winds reached 120 kn just southeast of her center. Several ships felt the wrath of Ella's fury. On the 5th, after she clipped Cape Race, Ella pounded the ST. LAWRENCE PROSPECT with 65-kn winds. Her central pressure had reached a low of 956 mb earlier. Gradually, the rapidly moving system began to weaken as it turned east-northeastward on the 5th. Cold air was also causing Ella to turn extratropical.

Casualties--The 166-ft fishing boat R.L. HANEY, JR. capsized and sank about 12 mi south of Biloxi, Miss. Of the 15 crewmembers, 1 drowned and 2 were missing. The seas were 6 to 7 ft with 20-kn winds at the time the boat was reported to have had a full load of fish. Another fishing boat, the GEORGIA BABY, rescued seven of the crew.

The 3,139-ton FAST BIRD of Greek registry sank off Alger on the 5th after a collision in fog with the Panamanian JESAMINE. The 870-ton Cypriot THEONIKA dragged anchors in heavy weather in Leghorn Roads on the 7th. She stranded on rocks and broke in two.

Smooth Log, North Pacific Weather

July and August 1978

SMOOTH LOG, JULY 1978--The cyclone track pattern was shifted westward from the climatic location. The concentration of cyclones that normally form in the vicinity of Japan was located over the continent over Mongolia and Manchuria. These generally remained over the land area, rather than tracking into the Bering Sea as the climatic pattern indicates. The storms that had their genesis over the marine area were spread out without a concentrated path, except that the majority terminated over the eastern Bering Sea and Alaska Peninsula. No significant low-pressure center penetrated the coastline east of 150°W.

The mean sea-level pressure chart for the month was dominated by the Pacific High. Its 1029-mb center was near 40°N, 145°W. This was 4 mb greater and 5° longitude east of its climatological position. Its influence also extended farther north and west than usual, including the Sea of Japan. A trough with a 1010-mb LOW near 54°N, 172°W, extended southeastward out of Siberia. The deepest LOW was 1002 mb and centered over the western shore of the Sea of Okhotsk.

There were five major anomaly centers that influenced the weather and its location or vice versa. The Pacific High produced two plus 4-mb centers--one over the eastern ocean near 44°N, 140°W, and the other near 43°N, 165°E. There were three negative centers: a minus 5 mb over the Aleutians near 170°W, a minus 6 mb collocated with the LOW on the western shore of the Sea of Okhotsk, and a minus 4 mb south of Japan near 25°N, 140°E.

The zonal flow at 700 mb was concentrated between latitudes 40° and 55°N. The High was near normal, but its influence extended farther west and north than usual. There was a low center over the Bering Sea, rather than a trough. This increased the sharpness of the ridge that normally exists over the northern North American west coast. The upper air anomaly centers closely matched those at the surface.

There were eight tropical cyclones, four over each ocean. There were typhoons Trix, Virginia, and Wendy and tropical storm Agnes over the western North Pacific. Tropical storm Emilia led off in the eastern North Pacific, followed by hurricanes Fico, Gilma, and Hector.

Extratropical Cyclones--Monster of the Month--The first storm of the month raced northeastward from between two HIGHs on the first day of the month. It was north of the Aleutians over the Bering Sea near 55°N, 175°W, by the first chart of the 2d. At that time the VAN ENTERPRISE was south of the islands near 51°N, 178°W, with 47-kn winds out of the west-southwest. The swell report indicated 41 ft.

By the 0000 chart of the 3d, the storm had absorbed four other small LOWs that were over the western Bering Sea and the Gulf of Alaska. There were many gale reports around the storm. The VAN ENTERPRISE now had 60-kn westerly winds, and the waves had dropped to 16 ft. The MARITIME BRILLIANCE (52°N, 139°W) was slapped by 54-kn southerly winds and 20-ft waves east of the storm and its fronts, while the MOBILE ARCTIC (55°N, 145°W) contended with 45-kn easterly winds and 30-ft waves. The report from a Japanese-registered ship near the occlusion indicated swells of 43 ft near 54°N, 151°W. Late on the 3d the storm was crossing the Alaska Peninsula with the pressure rising from its minimum of 982 mb.

On the 4th, 5th, and 6th the storm's center traced a counterclockwise loop just south of Kodiak Island. The maximum winds were in the gale range. By the 7th the LOW had yielded to high pressure.

A frontal wave developed at the point of occlusion of a front that extended southward out of a LOW over Siberia on the 6th. At 1200 on the 7th the 990-mb LOW was near 55°N, 177°W. The MARITIME BRILLIANCE was south of this storm at 53.5°N with 52-kn winds and 18-ft waves. The DALNIY VOSTOK (45°N, 166°W) had 50-kn winds. On the 8th this was a fairly large storm for a summer month. The GRECIAN SPIRIT was at 43°N, 174°W, with 35-kn gales. This was about 750 mi south of the center. The MARITIME BRILLIANCE was still sailing west south of the Aleutians into 45-kn gales. The storm was tracking eastward, but late in the day it swung northwestward over the Pribilof Islands to disappear over the Bering Sea on the 10th. The USCGC MELLON was near 59°N, 178°W, during this time with rain, drizzle, and fog.

During the first third of the month the Pacific High was firmly entrenched in the vicinity of 40°N, 140°W. The pressure gradient between the heat LOWs over the western desert area of the United States and the HIGH resulted in many northerly gale reports along the U.S. West Coast. The highest appeared to be 45 kn off Portland, Oreg. The EXXON SAN FRANCISCO

was north of the Golden Gate with 18-ft swells. Many of the higher winds and waves for the month were associated with this meteorological feature. On the 17th the SANTA CLARA was off Cape Mendocino with 50-kn northerly winds and 23-ft seas.

This frontal wave was a little different in that it originated on a warm front on the 25th. Most waves are found on the more unstable cold fronts. The LOW itself was not especially significant, except for the cold front it supported. The significant weather was confined to the area east of the front between the front and a stubborn HIGH centered in the area of 40°N, 160°W.

The LOW moved northeastward and at 0000 on the 26th was 1002 mb near 50°N, 163°E. At that time a SHIP was about midway between the two centers near 49°N, 179°W, and reported 58-kn winds out of the south. On the 27th the OSTROV CHOKALSKOVO was near 44°N, 177°E, with 28-ft swells. The winds in this area had been blowing from a southerly direction for several days as the HIGH drifted toward the south-southeast. Later in the day the analysis showed the HIGH had jumped southeastward; the LOW disappeared, but the front remained.

This LOW formed first in the upper air. The 700-mb chart for 0000 on the 27th had two weak LOWs--one off Vancouver Island and another over the Gulf of Alaska. By the 0000 chart of the 28th they had combined into one center near 56°N, 143°W. The 1800 surface chart of the 27th indicated a surface LOW near 49°N, 156°W. Both the surface and upper air LOWs deepened very rapidly. The VAN ENTERPRISE (50°N, 155°W) was less than 1° latitude from the center and was surprised by 62-kn easterly winds. The seas were 15 ft. She was sailing eastward, the same direction the storm was moving, and continued to have winds of about 60 kn, shifting to the north, until the 29th. On the 29th the NEW ENGLAND HUNTER was in the area of 45°N, 150°W, with 40-kn northwesterly winds and 13-ft waves. At 0600 the ARCO PRUDHOE BAY (51°N, 136°W) was headed into 40-kn southeasterly winds. On the 29th the storm started a counterclockwise loop under the upper air LOW, which was centered near 50°N, 145°W, and deepening. The surface LOW was 992 mb at 1200 with OWS Papa in the center.

The winds around the storm were now mainly in the breeze category. The next report of gale-force winds did not come until August 2, when the LEO near OWS Papa reported 40-kn westerlies. The LOW completed the circle and drifted toward the north. Both the surface and upper air LOWs were filling. The surface LOW disappeared from the analysis on the 5th, and the upper air LOW was gone on the 6th.

Tropical Cyclones, Eastern Pacific--Tropical storm Emilia survived less than 1 week. Beginning on the 6th near 15°N, 112°W, she moved west-northwestward for 5 days and dissipated near 22°N, 128°W. During this period winds near her center reached 50 kn during the 8th and 9th. While Emilia was weakening on the 9th, a new storm was brewing about 1,000 mi to the southeast. Fico came to life on the 9th near 10°N, 105°W. Unlike Emilia, he had a long life which took him on a journey south of the Hawaiian Islands and nearly across the dateline. In addition to being a long-lived storm--Fico lasted until the 28th--he was a powerful storm. On the 11th Fico reached hurricane intensity as he approached the 15th parallel. Winds near his center quickly intensified to 115 kn. Winds remained at about 100 kn or more for the next week as Fico headed westward. The size and intensity of Fico was attested to by the RACHEL which, although some 300 mi northeast of his center, battled giant 40-ft swells in 40- to 50-kn winds that were whipping 30-ft seas. Fico weakened briefly, but on the 20th as he neared the Hawaiian Islands, he regained his potency. The CHEVRON GENOA, southeast of the island of Hawaii near Fico, had 36-kn winds, 10-ft seas, and 16-ft swells. Fico remained about 180 mi south of the Islands as he swung toward the west-northwest. Maximum winds remained at 100 kn, and the Islands were pounded by heavy swell. By the 26th Fico showed signs of weakening as he crossed the 25th parallel near 175°W. For a while it looked like he might be the first storm to make it all the way from the eastern North Pacific across the dateline. However, he recurved northward and missed the dateline by a few hundred miles.

While Fico was traveling across the Pacific, two other tropical cyclones had come to life. Gilma formed on the 13th not more than 300 mi east of Fico's spawning ground. On the 22d Hector formed just 60 mi north of where Gilma developed. Both storms became hurricanes and traveled parallel paths. Gilma reached hurricane strength on the 15th near 15°N, 110°W, while Hector did the same on the 23d near 15°N, 105°W. Gilma peaked at about 90 kn from the 16th through the 18th. Hector's maximum winds topped out at about 110 kn on the 26th. At 1800 on the 25th the EXXON BOSTON (21.4°N, 109°W) was fighting 55-kn winds, 13-ft seas, and 23-ft swells. Gilma weakened to a depression on the 19th near 21°N, 127°W. Ten days later Hector was a depression about 60 mi to the northeast of this spot.

Tropical Cyclones, Western Pacific--Typhoon Trix popped up just east of the Volcano Islands on the 13th. After moving westward for a couple of days, she turned a counterclockwise loop on the 15th and 16th. By this time Trix was at typhoon strength. The HAMPTON MARU, within 60 mi of the center battled 20-ft waves. Trix remained at minimal typhoon strength for about 2 days. On the 19th as a tropical storm, she turned toward the west-northwest. At the 30th parallel she headed westward. By the 22d after moving through the northern Ryukyus, Trix weakened to a depression.

Typhoons Virginia, Wendy, and Agnes all formed during the 23d and 24th. Virginia and Wendy delivered a one-two punch to Japan at the end of the month, while Agnes belted Hong Kong on the 26th. Agnes formed just 200 mi south of Hong Kong and developed rapidly. Although she was considered a tropical storm, it is more likely that she reached typhoon strength. On the 26th the AMERICAN APOLLO, close to her center, ran into 60-kn winds in 25-ft seas. Around the colony winds up to 97 kn were reported; trees were uprooted, scaffoldings blown down, and up to 7 in of rain fell leaving 126 injured. Agnes turned a counterclockwise loop and moved close to Hong Kong again on the 29th, as she headed for the China mainland. This second blow left 3 dead and 80 injured. Winds were only up to 45 kn, but over 17 in of rain fell.

Meanwhile, both Virginia and Wendy had reached typhoon strength and were tracking northwestward. Several Japanese ships, including the KUNIMISAN, NICHIJU, and HAMPTON MARU, battled 40- to 55-kn winds in 20-ft seas along Wendy's path. Wendy had come to life in the northern Philippine Sea and passed through the Ryukyus on the 28th. Maximum winds reached 75 kn near her center. On the 28th the PRESIDENT MADISON discovered 35-kn winds and 17-ft seas about 330 mi west of the eye. On the 29th the PRESIDENT FILLMORE was 240 mi east of the eye with 42-kn gales, 21-ft seas, and 26-ft swells. Presidential ships were bracketing the storm. The 12,299-ton Cypriot-registered ALAMAR ran aground at 33.5°N, 126.9°E, on the 31st.

Virginia's winds ranged from 65 to 70 kn as she approached Tokyo on the 31st. For several days prior to this the VOLNA, JUJO MARU, and ARIAKE 1 battled 30- to 50-kn winds in 20-ft swells generated by Virginia. Virginia brushed Honshu on August 1 as she recurved toward the east-northeast. The following day she was weakening rapidly. This same day she recurved toward the east-northeast. The PRESIDENT JOHNSON (fig. 34) (38°N, 143°W) was nearing Yokohama at 1800 on the 1st, when the storm passed

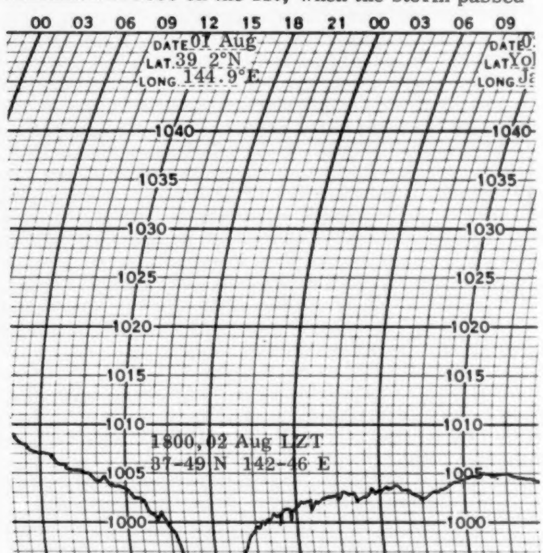

Figure 34.--Barogram of PRESIDENT JOHNSON.

southeast of her. The winds were only 20 kn and the seas 16 ft, but the pressure plunged to 980 mb. The following day she was weakening rapildy. This same day saw Wendy, now a tropical storm, recurve northeastward and move over Kyushu. There was little damage from either storm, but the warm flow triggered by Wendy combined with a foehn wind and touched off a heat wave across western Honshu. Temperatures were driven into the upper 90's (°F) and even to 100°F in some places.

Casualties--Fog was the culprit this month. On the 3d the 998-ton CHIYO MARU No. 11 and the newly built 19,364-ton Greek OINOUSSIAN VIRTUE collided in fog off Shodoshima. The CHIYO MARU was heavily damaged. The Canadian supply vessel ARCTIC PELLY reported at Tuktoyaktuk (Beaufort Sea in the Mackenzie River Delta) with freezing damage.

The two Korean vessels TOSONG and FLOWER collided in dense fog near 35.1°N, 129.3°E. The 13,255-ton Greek-registered STAR K. (fig. 35) and the 15,024-ton Singapore-registered TAIWAN PHOENIX (fig. 36) collided 600 mi south of Kodiak on the 19th, apparently in fog. The USCGC JARVIS was in the vicinity and standing by. Both ships were towed to the West Coast, the STAR K. stern first.

The American tanker GAINES MILL, which capsized off Kaohsiung in typhoon Thelma (July 25, 1977) while being towed to be scrapped, was refloated on July 22, 1978, almost a year later.

Figure 35.--A view of the bow of the STAR K. U.S. Coast Guard Photo.

Figure 36.--A similar view of the bow of the TAIWAN PHOENIX. U.S. Coast Guard Photo.

SMOOTH LOG, AUGUST 1978--The mean storm tracks this month differed considerably from the climatic mean. Normally, there is a track out of Asia across the Gulf of Terpeniya to the Kurile Islands. Another track heads northeastward from about 600 mi off Tokyo to the Aleutians near 180° and then eastward into the Gulf of Alaska.

This month the mean track moved eastward from the vicinity of Hokkaido to near 45°N, 170°E, and then curved sharply northeastward toward Bristol Bay. A secondary track came across the Sea of Okhotsk to the Bering Sea.

The main pressure feature was the Pacific High at 1026 mb centered near 40°N, 150°W. This is within a few miles and 2 mb of being normal. The Aleutian Low is normally 1008 mb near 60°N, 175°E. This month it was 1002 mb near 56°N, 167°E.

The anomalies south of 40°N were generally positive and only 0 to 3 mb. There were two negative anomaly centers north of 40°N. The largest was minus 7 mb and collocated with the position of the Aleutian Low. The other was minus 4 mb and centered near 50°N, 140°W.

In the upper air at 700 mb the main feature was a closed-Low center corresponding to the Aleutian Low. This is normally only a trough out of the Polar Low. A second closed-Low center was over the Gulf of Alaska near 55°N, 143°W. This last center was truly anomalous as there is usually a ridging effect in this area. The closed LOW over the Bering Sea produced a pronounced ridge over western Alaska. The LOW over the Gulf of Alaska accentuated the usual trough off the North American west coast.

There were six tropical cyclones over the eastern ocean--four hurricanes and two tropical storms. In the western ocean, there were seven tropical cyclones of which three were typhoons and four were tropical storms.

Extratropical Cyclones--The month began with two tropical cyclones straddling Japan. Wendy came in from the west toward Kyushu, and Virginia traveled northward off the east coast. By the 3d both had deteriorated to tropical depressions. By 1200 both had been dropped from the analysis. At this time a LOW developed over the Sea of Japan west of Hokkaido.

At 0600 on the 4th the NIKOLAI ISSAIENKO was off Nemuro with 40-kn southwesterly winds. The storm moved east-northeastward and at 0000 on the 5th was 983 mb near 49°N, 155°E, over the Kurile Islands. The weather station on Ostrov Urup measured 35-kn winds. On the 6th there were many reports of gale-force winds. Early in the day the ORIENTAL SOVERIGN was very near the storm's center with a pressure of 985 mb and 42-kn winds. The center of the storm was estimated at 983 mb. Not too far away the IONIAN LEADER reported 33-ft seas. At 1200 the SCHERPENDRECHT (47°N, 172°E) was about 400 mi south of the center with 50-kn winds and 21-ft swells.

On the 7th a SHIP near 49°N, 169°E, was sailing directly into 40-kn winds and 15-ft seas. The seas and swells were reported to be 20 ft by the FORTUNE LEADER. She was west of the cold front near 46°N, 178°E. Later in the day another LOW moved into the southwestern quadrant, and the center looped counterclockwise as the two combined over the Bering Sea. The storm had weakened to a pressure of 996 mb with a weak pressure gradient.

The LOW crossed the Alaska Peninsula into the Gulf of Alaska on the 10th. On the 12th it crossed the coast near Queen Charlotte Island.

This cyclone developed as a frontal wave late on the 4th and first appeared on the 0000 chart of the 5th, near 45°N, 174°W. It deepened rapidly, and by 0000 on the 6th it was 984 mb. There were quite a few ships caught in the gale-force winds. On the 5th the OGDEN CONGO (44°N, 169°W) and the JAPAN RAINBOW (45°N, 158°W) both measured 45-kn southwesterly winds and seas of 16 to 21 ft. The JAPAN RAINBOW was sailing eastward with the storm and on the 6th measured 48-kn winds with 17-ft seas. On the 7th a ship southwest of the center had 18-ft swells, and another ship 500 mi south of the center found 25-ft waves near 41°N, 147°W. On the 8th the storm was filling near 50°N, 145°W, and turning northward. By the close of the 9th, the center had disappeared near Kodiak Island.

Another storm that formed over the Sea of Japan off Hokkaido. This LOW began as a frontal wave on the 16th. The LOW raced eastward and treated the NEPTUNE DIAMOND to 40-kn westerlies. By 1200 on the 18th the 982-mb storm was near 51°N, 170°E. It did not have a large circulation at this time, but the gradient was tight for this time of year. The ASIA MARU was sailing westward into 40-kn gales. On the 19th there were several wind reports in the 40-kn category. The VAN ENTERPRISE reported 47-kn winds at 48°N, 159°E. At least two ships were pounded by 20-ft waves on this day. The ALSTER EXPRESS east of the storm and north of Adak had 44-kn winds with 20-ft seas and the GREEN AUKLET was pounded by 30-ft seas south of the Fox Islands. St. Paul Island measured 40-kn prevailing winds on the 20th. At 1200 Bethel, Alaska, also measured 40-kn winds. The storm's center passed over the coast near Nome at about 0800. Early on the 21st the LOW disappeared.

As the front associated with the LOW above moved to the south, a frontal wave formed between two HIGH cells late on the 19th. On the 21st it was moving almost due north, and there were several reports of gales. The CGC STORIS (52°N, 173°W) had 38 kn. Twelve degrees of latitude to the south (40°N, 173°W) the ASIA HONESTY found 55-kn winds and 21-ft seas. On the 22d the 990-mb LOW moved to 54°N, 171°E. West of the front a ship reported 16-ft seas. The MAJESTY was many miles to the south, slightly east of the north-south-oriented front, with 40-kn winds. The PRESIDENT PIERCE was south of the Aleutians and east of the front with southeasterly winds of 55 kn. The storm was now moving westward and weakening. It managed to survive into the 24th, turning back eastward for a few hours.

Back again to the Sea of Japan for the genesis of this storm, which formed over the Tartar Strait on the 23d. The LOW moved southeast prior to turning northward on the 24th after crossing the Kurile Islands. As this LOW moved northward it absorbed the remains of the LOW described above. The gradient to the east of the LOW and front was much tighter than it was on the western side. At 0000 on the 25th the LEO was

near 49°N, 166°E. She reported being pounded by 58-kn southerly winds. The LOW continued paralleling the coast of Asia until it disappeared.

Tropical Cyclones, Eastern Pacific--Hurricane Iva was detected on the 11th some 200 mi west of Manzanillo. Tracking west-northwestward, she attained hurricane status for a brief period on the 13th. The following day Iva was only tropical storm strength and weakening.

Hurricanes John and Kristy both came to life on the 18th, while tropical storm Lane was born 1 day later. John was in the middle of this near 12°N, 120°W. Kristy was about 600 mi to the east-northeast, while Lane was about 900 mi to the west. John and Kristy moved west-northwestward for several days before joining Lane on a westerly course. John and Lane passed south of the Hawaiian Islands, while Kristy swung to the west-northwest again and passed northeast of the Islands. Kristy reached hurricane strength on the 19th, while John waited until the 22d. By this time Lane had reached his peak of 50 kn and was declining as he moved westward along the 14th parallel near 150°W. Kristy was crossing the 120th meridian near 18°N sporting 90-kn winds. Lane faded out by the 24th, while Kristy was generating 80-kn winds and John's winds climbed to 90 kn. The following day Kristy weakened to tropical storm strength as she crossed the 20th parallel near 135°W. John retained hurricane strength until the 26th, but then he began to slip. Kristy lasted until the 28th. John, cruising south of Hawaii along 15°N, hung on until the 30th across 170°W.

While our trio of storms was forging westward toward Hawaii, Miriam was developing around 10°N, 115°W, on the 24th. Remaining a depression until the 27th, Miriam traveled west-northwestward and reached 135°W, where she became a tropical storm. From here on Miriam covered the same waters as Lane and John less than a week before. Miriam reached a peak of 55 kn on the 28th as she crossed 140°W near 13°N. The MARGUERITE VENTURE was caught by the storm near 13°N, 139.4°W, not far from its center with measured 35-kn winds and 20-ft waves. Upon reaching 15°N the following day, Miriam tracked westward slowly dissipating and remaining south of Hawaii. By the 1st she was dissipating near 14°N, 160°W.

As Miriam weakened, Norman came to life on the 30th several hundred miles south of the Gulf of Tehuantepec. He developed rapidly and became a real threat to the fishing fleet. On the 1st and 2d several ships between hurricane Norman and the coast were blasted by 40- to 45-kn winds while cruising in 15- to 30-ft seas. The TEMPLE INN was among these ships. One ship reported 17-ft seas and 38-ft swells about 120 mi northeast of the center. Winds near Norman's center were up to 120 kn by the 3d as he crossed 20°N near 113°W. Norman was paralleling the coast. Although he could not keep his extreme intensity, Norman remained at hurricane strength until late on the 4th near 25°N, 120°W. After this he weakened rapidly as he neared the coast of southern California. Despite this, Norman's rain shield spread to northern California and most of the northwest corner of the Nation. The rain was light but widespread. Almost an inch fell at Strevell, Idaho.

Tropical Cyclones, Western Pacific--Bonnie was spotted moving westward on the 10th in the South China Sea, about 200 mi east of Hainan. The tropical storm crossed Hainan on the 11th. The following day she moved into northern Vietnam. Bonnie's winds reached 40 kn on the 11th.

By this time Carmen and Della were already developing far to the east. Della was detected 300 mi east of Luzon, while Carmen was spotted just north of Saipan. The PRESIDENT JACKSON tasted 40-kn easterly winds and 13-ft waves near 23°N, 125°E, as Della developed. Early on the 13th the OHIKUZEN MARU, some 150 mi northeast of Carmen's center, battled 30-ft swells in 35-kn winds. Carmen was upgraded to a typhoon at this time near 20°N, 140°E. Meanwhile, Della was moving across Taiwan as a 40-kn tropical storm. The rugged island disrupted her circulation, and she limped ashore on the China mainland late on the 13th as a tropical depression. Carmen roared west-northwestward through the Ryukyus, near Okinawa, packing 75-kn winds. The USNS UTE encountered 40-kn winds late on the 13th some 100 mi to the north of Carmen's center. The East China Sea slowed her down. She began to weaken, and on the 17th she turned northward as a tropical storm. On the 20th Carmen lashed the southwestern tip of the Korean peninsula with torrential rains, flooding farms, villages, and towns. There were 20 deaths with 8 people missing and 4,180 homeless. Property damage was estimated at $20 million.

On the 24th the MAASKADE was sailing through the Luzon Strait into 44-kn winds out of the east-northeast. This was the beginning of Elaine who had formed just east of northern Luzon the day before. She moved across the Island and out into the South China Sea, where she intensified and headed west-northwestward. During her 3-1/2 day crossing to mainland China, several ships encountered 20-ft seas and 35- to 50-kn winds. Elaine reached her peak, 65-kn typhoon intensity, just before landfall east of the Lei-chou peninsula on the 27th. The SEA-LAND TRADE was in Hong Kong and evacuated to sea to ride out Elaine. Her barograph dropped to 972 mb (fig. 37) during the passage, and the winds were up to 65 kn at 0600 with 36-ft swell waves. The ship returned to Hong Kong after the storm passed. Before she dissipated, Elaine made it westward into northern Vietnam on the 28th. (Continued on page 47.)

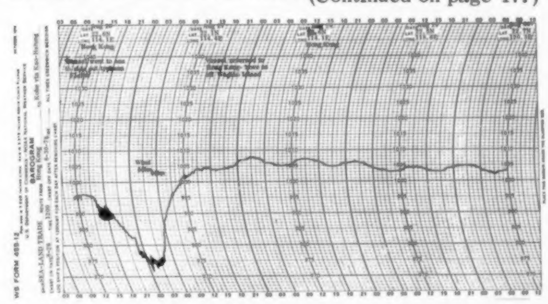

Figure 37.--This barogram from the SEA-LAND TRADE shows the trace of Elaine as the ship was evacuated from Hong Kong during the typhoon's passage.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

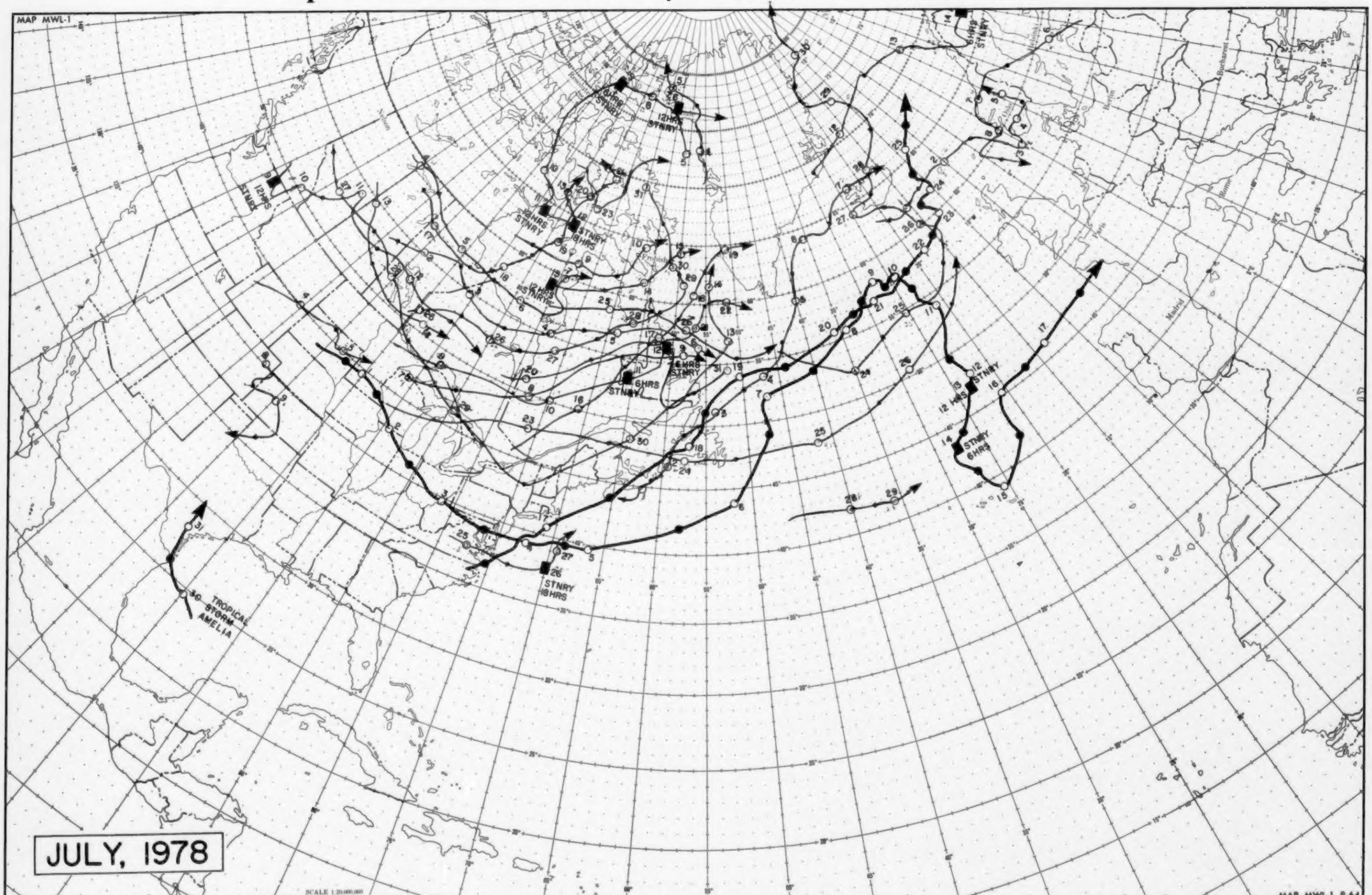

Figure 38.---Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

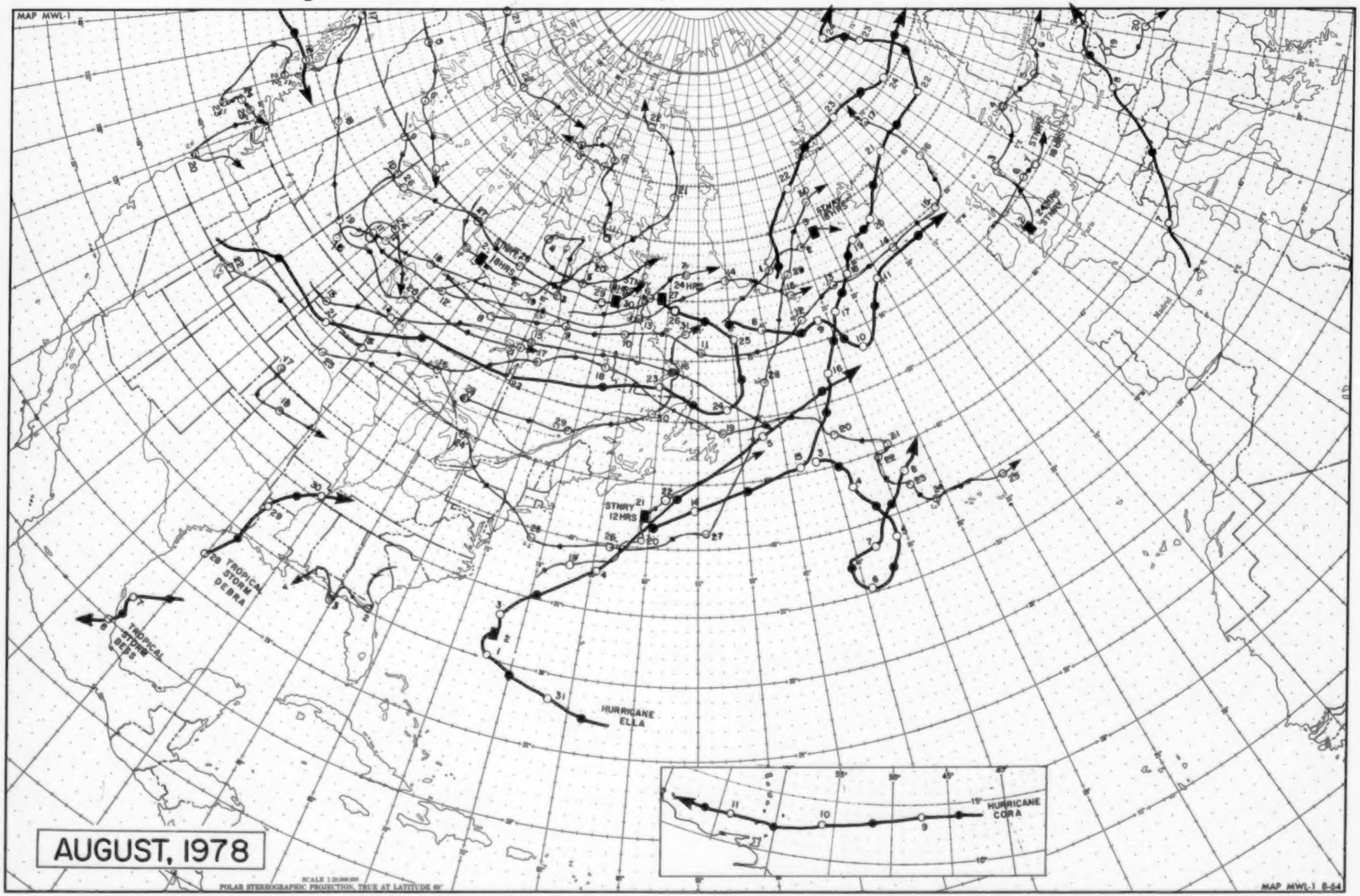

Figure 39.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

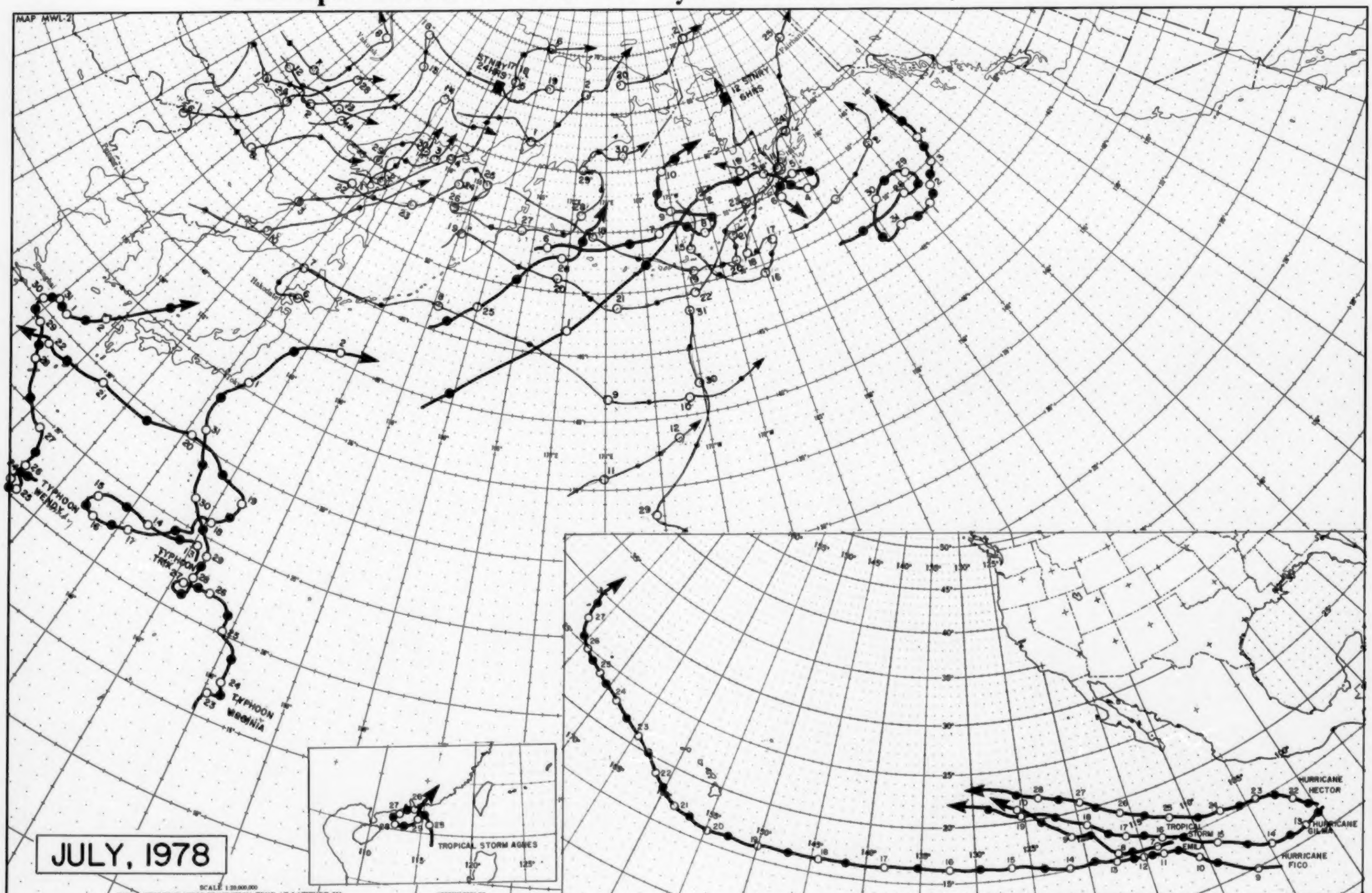

Figure 40. -- Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

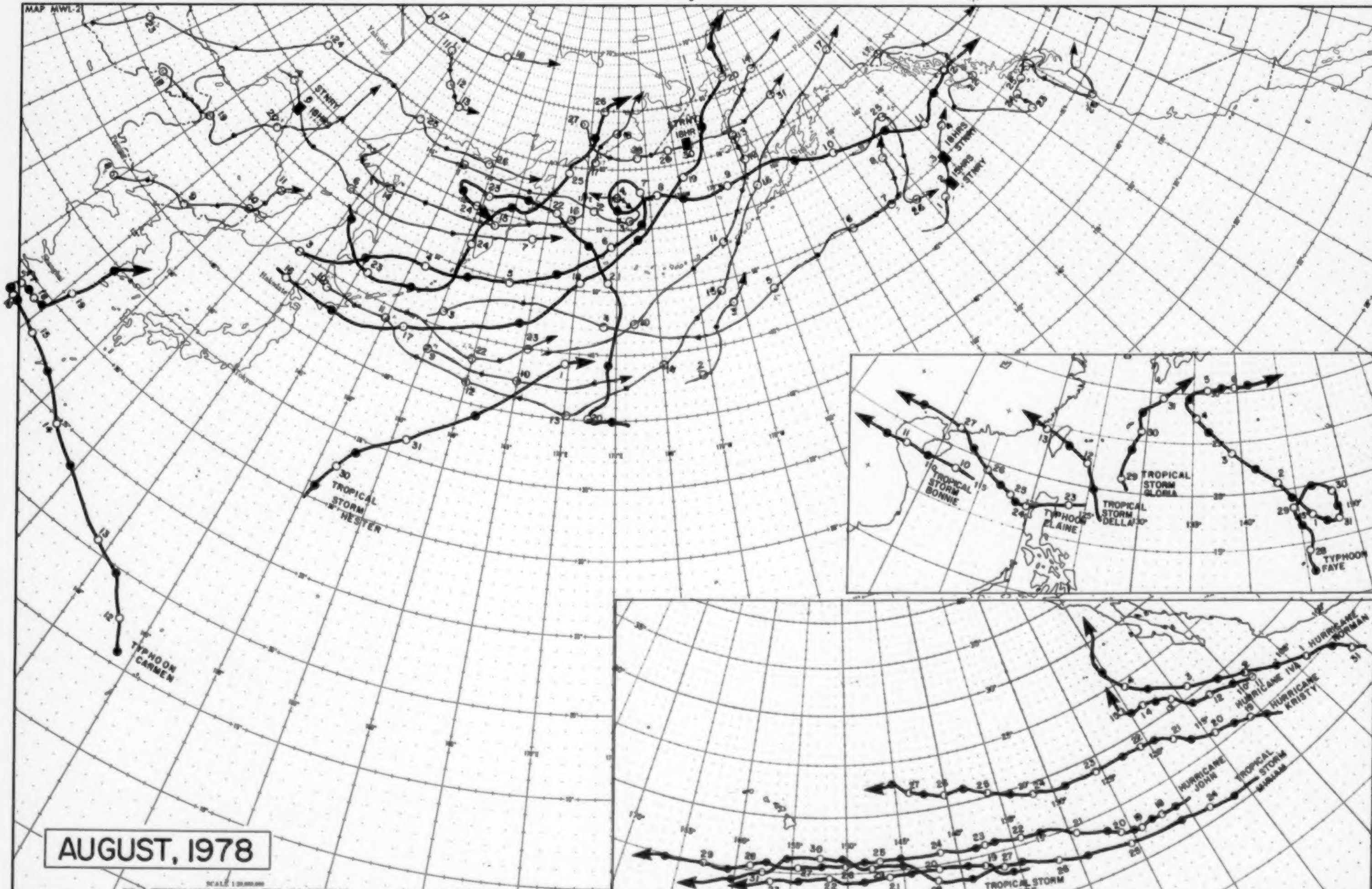

Figure 41.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Table 5
U.S. Ocean Buoy Climatological Data
July and August 1978

JULY — DATA SUMMARY — 41001
AVERAGE LATITUDE 35.0N — AVERAGE LONGITUDE 072.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	21.8	(06 03)	25.3	27.9	(31 21)	248	31
SEA TEMP (DEG C)	24.9	(06 12)	26.2	27.8	(27 18)	248	31
AIR-SEA TEMP (DEG C)	-04.1	(28 00)	-00.9	C0.5	(22 21)	248	31
PRESSURE (MBAR)	1010.6	(04 08)	1018.3	1024.3	(20 15)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 248

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		1.2	4.8				6.0	12.9
NE		2.0	2.8				4.8	12.1
E		7.3	7.3				14.5	11.5
SE		4.0	1.2				5.2	7.7
S	.8	4.4	5.6	1.2			12.1	12.9
SW	.8	5.6	34.7	2.8			44.0	15.7
W	.4	3.8	4.0				8.1	10.7
NW		1.6	3.2				4.8	11.8
CALM	.4						.4	.0
TOTAL	2.4	28.8	63.7	4.0			100.0	13.3

MAX WIND
SPEED: 30 KNOTS
DIRECTION: 210 DEG
DAY: 28
HOUR: 21

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 247

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	2.8	81.8	15.4						1.3M	2.5M	(28 12)

JULY — DATA SUMMARY — 41004
AVERAGE LATITUDE 32.6N — AVERAGE LONGITUDE 078.7W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	22.5	(03 00)	26.8	28.8	(22 18)	240	31
SEA TEMP (DEG C)	26.6	(17 12)	27.7	30.7	(22 21)	240	31
AIR-SEA TEMP (DEG C)	-05.5	(03 00)	-00.8	00.6	(18 18)	240	31
PRESSURE (MBAR)	1008.7	(03 21)	1017.5	1024.2	(23 15)	240	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 84

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N			1.2				1.2	17.1
NE			3.6				3.6	16.7
E		4.8	18.0				23.8	13.7
SE		1.2	1.2				2.4	8.5
S		2.4	3.6				6.0	11.4
SW		15.5	39.3				54.8	12.5
W		1.2	6.0				7.1	13.4
NW								
CALM	1.2						1.2	.0
TOTAL	1.2	25.0	73.8				100.0	12.8

MAX WIND
SPEED: 18 KNOTS
DIRECTION: 070 DEG
DAY: 06
HOUR: 12

JULY — DATA SUMMARY — 42001
AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 090.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	23.8	(21 15)	28.3	30.0	(03 00)	252	31
SEA TEMP (DEG C)	28.6	(24 18)	28.3	30.3	(12 00)	146	20
AIR-SEA TEMP (DEG C)	-06.4	(21 15)	-01.2	C0.0	(12 00)	144	20
PRESSURE (MBAR)	1010.5	(17 09)	1016.7	1021.3	(26 03)	235	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 230

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	3.0	.9					3.9	3.3
NE	3.5	1.7					5.2	5.2
E	7.0	12.2	1.3				20.4	4.8
SE	10.8	18.8	3.0				33.5	5.2
S	7.4	15.2	.9	.4			23.9	5.4
SW	1.7	3.0	.4				5.2	5.4
W	.9	.9	.9				2.6	6.5
NW	1.7	.4					2.2	3.0
CALM	3.0						3.0	.0
TOTAL	38.1	53.0	6.5	.4			100.0	4.8

MAX WIND
SPEED: 22 KNOTS
DIRECTION: 180 DEG
DAY: 31
HOUR: 15

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 204

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	72.1	27.8							.8M	1.5M	(24 08)

JULY — DATA SUMMARY — 42002
AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 093.5W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	23.1	(21 21)	28.6	31.1	(16 00)	183	24
SEA TEMP (DEG C)	28.8	(01 12)	28.8	31.7	(17 18)	183	24
AIR-SEA TEMP (DEG C)	-08.4	(21 21)	-01.2	-00.1	(02 00)	183	24
PRESSURE (MBAR)	1010.6	(17 08)	1015.6	1018.5	(07 18)	182	24

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 183

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	1.6	1.1					2.7	4.0
NE	1.6	.5	.5				2.7	5.4
E	4.4	12.0	3.3				19.7	6.6
SE	5.5	23.0	7.7				36.1	7.1
S	3.3	21.9	4.4				29.5	7.1
SW	1.6	2.7					4.4	5.4
W	.5	1.1					1.6	3.7
NW	1.1	.5					1.6	3.7
CALM	1.6						1.6	.0
TOTAL	21.3	62.8	15.8				100.0	6.6

MAX WIND
SPEED: 18 KNOTS
DIRECTION: 140 DEG
DAY: 19
HOUR: 12

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 180

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	78.3	21.7							.6M	1.5M	(22 08)

JULY — DATA SUMMARY — 42003
AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 088.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	24.0	(20 18)	28.1	30.4	(19 21)	245	31
SEA TEMP (DEG C)	28.3	(26 12)	29.5	31.8	(04 21)	245	31
AIR-SEA TEMP (DEG C)	-04.7	(20 18)	-01.4	C0.1	(12 12)	245	31
PRESSURE (MBAR)	1011.7	(17 09)	1017.6	1021.8	(25 03)	245	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 244

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	2.0	3.7					5.7	4.7
NE	4.1	5.3					9.4	4.9
E	7.4	20.5	11.1				38.9	7.7
SE	4.1	11.5	2.0				17.6	5.7
S	4.1	9.4	2.0				15.6	7.3
SW	1.6	3.3	1.2				6.1	6.8
W	1.2	1.6	.4				3.3	6.6
NW	.8	1.2	.4				2.5	5.5
CALM	.8						.8	.0
TOTAL	26.2	56.6	17.2				100.0	6.8

MAX WIND
SPEED: 21 KNOTS
DIRECTION: 180 DEG
DAY: 27
HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	72.1	27.9							.6M	1.5M	(28 08)

AUGUST — DATA SUMMARY — 41001
AVERAGE LATITUDE 35.0N — AVERAGE LONGITUDE 072.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	23.6	(13 15)	26.8	30.0	(17 18)	248	31
SEA TEMP (DEG C)	27.1	(13 15)	28.0	30.3	(16 21)	248	31
AIR-SEA TEMP (DEG C)	-03.8	(12 08)	-01.2	C0.4	(18 15)	248	31
PRESSURE (MBAR)	1014.3	(18 08)	1020.5	1027.7	(06 15)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 248

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		1.2	1.6	.4			3.2	12.4
NE		4.0	4.0				8.1	10.4
E	1.2	2.8	.8				4.8	8.6
SE	1.2	8.1	2.4				11.7	8.7
S	.8	12.1	16.8				29.8	11.1
SW	1.2	8.7	12.1				23.0	10.9
W		8.9	4.0				12.9	9.8
NW	.4	3.2	1.2				4.8	7.8
CALM	1.6						1.6	.0
TOTAL	6.5	50.0	43.1	.4			100.0	10.0

MAX WIND
SPEED: 25 KNOTS
DIRECTION: 010 DEG
DAY: 18
HOUR: 12

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 247

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	1.2	98.0	.8						1.1M	2.0M	(13 15)

AUGUST — DATA SUMMARY — 41004
AVERAGE LATITUDE 32.6N — AVERAGE LONGITUDE 078.7W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	24.8	(12 15)	27.4	28.6	(18 21)	245	31
SEA TEMP (DEG C)	26.4	(24 06)	28.0	30.1	(18 21)	245	31
AIR-SEA TEMP (DEG C)	-03.0	(12 15)	-00.6	C0.8	(26 15)	245	31
PRESSURE (MBAR)	1014.8	(18 08)	1018.4	1024.7	(07 15)	245	31

AUGUST — DATA SUMMARY — 42001
AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 090.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	23.8	(04 12)	28.3	30.1	(17 15)	241	31
SEA TEMP (DEG C)	28.2	(08 03)	28.2	30.8	(12 00)	210	31
AIR-SEA TEMP (DEG C)	-05.3	(04 12)	-01.0	C1.5	(17 15)	210	31
PRESSURE (MBAR)	1011.6	(27 00)	1016.7	1020.5	(20 18)	241	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 241

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	2.9	.4				3.7	6.1
NE	3.7	12.4	1.7				17.8	5.4
E	6.2	23.7	5.4				35.3	6.4
SE	2.9	16.2	7.1	.4			26.6	8.0
S	1.2	8.7	2.9	.4			13.3	7.7
SW	.4	1.7	.4				2.5	6.2
W	.4						.4	2.0
NW		.4					.4	6.0
CALM								
TOTAL	15.4	66.0	17.8	.8			100.0	6.8

MAX WIND
SPEED: 22 KNOTS
DIRECTION: 180 DEG
DAY: 28
HOUR: 12

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 201

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	66.7	22.9	6.5	3.5	.5				.9M	4.0M	(27 12)

AUGUST — DATA SUMMARY — 42002
AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 093.5W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	24.3	(28 08)	28.5	29.9	(21 18)	117	16
SEA TEMP (DEG C)	28.8	(31 12)	28.4	30.2	(22 21)	117	16
AIR-SEA TEMP (DEG C)	-04.8	(28 08)	-00.9	C0.1	(31 15)	117	16
PRESSURE (MBAR)	1008.2	(28 09)	1015.3	1020.1	(21 18)	117	16

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 117

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.9	1.7					2.6	4.7
NE	.9	10.3	1.7				12.8	7.1
E	1.7	34.2	6.8				42.7	7.9
SE	.9	20.5	4.3	.9			26.5	7.9
S	.9	4.3	6.0	1.7			12.8	11.9
SW		1.7					1.7	7.0
W								
NW	.9						.9	3.0
CALM								
TOTAL	6.0	72.6	18.8	2.6			100.0	8.2

MAX WIND
SPEED: 27 KNOTS
DIRECTION: 180 DEG
DAY: 28
HOUR: 15

AUGUST — DATA SUMMARY — 42003
AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 088.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	24.2	(26 15)	28.2	29.9	(11 21)	248	31
SEA TEMP (DEG C)	27.6	(28 12)	29.2	30.9	(12 21)	248	31
AIR-SEA TEMP (DEG C)	-04.6	(26 15)	-01.0	C0.7	(27 21)	248	31
PRESSURE (MBAR)	1014.3	(25 08)	1017.7	1021.4	(15 15)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 248

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	1.6	5.2					6.9	5.6
NE	1.6	15.7	2.8				20.2	7.9
E	4.8	27.0	10.5				42.3	7.8
SE	2.0	12.9	6.5				21.4	8.7
S	1.6	4.4	.4				6.5	6.2
SW	.4	.4					.8	3.5
W		.4					.4	4.0
NW		.4					.4	4.0
CALM	1.2						1.2	.0
TOTAL	13.3	66.5	20.2				100.0	7.6

MAX WIND
SPEED: 18 KNOTS
DIRECTION: 110 DEG
DAY: 27
HOUR: 15

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 237

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	73.8	24.1	2.1						.7M	2.0M	(27 08)

JULY — DATA SUMMARY — 44001

AVERAGE LATITUDE 38.7N — AVERAGE LONGITUDE 073.6W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	18.8	(13 00)	22.2	24.2	(28 06)	51	8
SEA TEMP (DEG C)	19.6	(15 08)	21.8	23.4	(28 18)	51	8
AIR-SEA TEMP (DEG C)	-01.1	(28 18)	00.3	C1.8	(28 06)	51	8
PRESSURE (MBAR)	1008.5	(30 08)	1014.8	1022.8	(13 15)	51	8

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 51

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		3.8					3.8	5.0
NE		3.8					3.8	5.5
E		5.8	3.9				9.8	10.6
SE	2.0	2.0	2.0				5.9	10.0
S		13.7	9.8				23.5	10.4
SW		13.7	15.7				29.4	10.8
W		17.6	2.0				19.6	8.3
NW		3.8					3.8	5.5
CALM								
TOTAL	2.0	64.7	33.3				100.0	9.2

MAX WIND — SPEED: 17 KNOTS; DIRECTION: 120 DEG; DAY: 31; HOUR: 15

AUGUST — DATA SUMMARY — 44001

AVERAGE LATITUDE 38.7N — AVERAGE LONGITUDE 073.6W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	21.2	(27 00)	24.8	27.3	(17 21)	247	31
SEA TEMP (DEG C)	22.5	(28 03)	24.8	27.1	(14 21)	247	31
AIR-SEA TEMP (DEG C)	-02.7	(26 08)	00.0	C2.0	(28 03)	247	31
PRESSURE (MBAR)	1010.6	(20 08)	1018.2	1025.5	(06 15)	247	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 242

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	1.2	3.7				5.4	11.5
NE	1.7	5.8	2.1				9.5	7.1
E	3.3	1.2	.4				5.0	3.3
SE	2.9	2.9					5.8	3.7
S	2.5	18.0	4.5				26.0	7.2
SW	1.7	18.1	14.0				31.8	10.2
W	.8	7.4	1.2				9.5	7.0
NW	.8	2.5	.4				3.7	6.0
CALM	3.3						3.3	.0
TOTAL	17.4	56.2	26.4				100.0	7.7

MAX WIND — SPEED: 20 KNOTS; DIRECTION: 030 DEG; DAY: 21; HOUR: 08

JULY — DATA SUMMARY — 44002

AVERAGE LATITUDE 40.1N — AVERAGE LONGITUDE 073.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	14.6	(05 00)	20.3	24.8	(24 00)	218	31
SEA TEMP (DEG C)	15.5	(06 08)	20.0	23.5	(28 21)	216	31
AIR-SEA TEMP (DEG C)	-01.8	(21 15)	00.3	C2.4	(11 00)	213	31
PRESSURE (MBAR)	1005.2	(04 06)	1016.0	1024.4	(20 06)	218	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 201

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		2.5	5.5	.5			8.5	13.1
NE		2.5	1.5	1.0			5.0	12.8
E	.5	8.0	6.5	1.0			15.8	11.2
SE	.5	3.0	.5				4.0	8.4
S		24.8	12.4				37.3	8.6
SW		12.4	6.5				18.9	8.3
W	1.0	3.0	.5				4.5	6.7
NW		3.5	2.0				5.5	10.0
CALM	.5						.5	.0
TOTAL	2.5	59.7	35.3	2.5			100.0	10.0

MAX WIND — SPEED: 27 KNOTS; DIRECTION: 030 DEG; DAY: 04; HOUR: 18

AUGUST — DATA SUMMARY — 44002

AVERAGE LATITUDE 40.1N — AVERAGE LONGITUDE 073.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	18.5	(26 15)	23.2	26.4	(18 03)	235	31
SEA TEMP (DEG C)	21.1	(26 15)	23.5	26.8	(18 21)	232	31
AIR-SEA TEMP (DEG C)	-03.1	(12 15)	-00.3	C1.8	(28 03)	232	31
PRESSURE (MBAR)	1008.2	(20 08)	1018.0	1026.0	(05 15)	231	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 220

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.5	6.4	3.2	.5			10.5	10.3
NE	1.0	3.2	5.0				10.0	10.2
E		8.6	1.8				10.5	8.4
SE	1.0	3.6	1.4				6.0	6.8
S	.5	15.0	16.4				31.8	10.6
SW	.9	10.5	7.3				18.6	8.4
W	.5	5.5	.5				6.4	6.5
NW	.9	3.6	.9				5.5	6.0
CALM								
TOTAL	6.0	58.4	36.4	.5			100.0	8.4

MAX WIND — SPEED: 22 KNOTS; DIRECTION: 360 DEG; DAY: 21; HOUR: 06

JULY — DATA SUMMARY — 44003

AVERAGE LATITUDE 40.8N — AVERAGE LONGITUDE 068.5W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	11.2	(06 08)	13.1	15.3	(08 12)	68	10
SEA TEMP (DEG C)	08.8	(01 12)	10.8	12.1	(02 21)	68	10
AIR-SEA TEMP (DEG C)	00.5	(06 08)	02.2	C4.0	(09 08)	68	10
PRESSURE (MBAR)	1007.2	(05 08)	1018.7	1023.4	(07 15)	69	10

AUGUST — DATA SUMMARY — 44003

AVERAGE LATITUDE 40.8N — AVERAGE LONGITUDE 068.5W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	12.4	(23 06)	16.3	18.7	(31 18)	174	24
SEA TEMP (DEG C)	12.4	(13 12)	13.8	17.1	(26 21)	168	24
AIR-SEA TEMP (DEG C)	-01.3	(27 03)	02.3	C6.5	(17 00)	167	24
PRESSURE (MBAR)	1010.3	(28 18)	1017.4	1023.2	(08 03)	174	24

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 172

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.6	6.4	.6				7.6	6.8
NE	1.7	3.5	5.8				11.0	10.3
E	.6	7.6	1.2				9.3	6.8
SE		4.1	1.7				5.8	8.2
S	2.3	8.1	6.4				16.8	8.8
SW	1.7	16.3	10.5				28.5	8.8
W	2.3	8.7	.6				11.6	5.8
NW	2.9	6.4					9.3	5.1
CALM								
TOTAL	12.2	61.0	26.7				100.0	7.8

MAX WIND — SPEED: 17 KNOTS; DIRECTION: 030 DEG; DAY: 26; HOUR: 08

JULY — DATA SUMMARY — 44004

AVERAGE LATITUDE 38.0N — AVERAGE LONGITUDE 070.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	16.3	(05 21)	22.3	24.8	(28 06)	247	31
SEA TEMP (DEG C)	21.8	(06 08)	23.3	25.4	(28 18)	247	31
AIR-SEA TEMP (DEG C)	-06.4	(05 15)	-01.0	C1.0	(11 06)	247	31
PRESSURE (MBAR)	1004.7	(05 06)	1018.2	1025.8	(18 15)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 248

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		.8	4.9	2.8			8.5	17.5
NE		.4	5.2				5.6	16.1
E	.8	2.8	5.6	2.4			11.7	15.1
SE	.4	6.8	1.2				8.5	8.4
S	.8	9.3	10.9	.4			21.4	11.1
SW		8.5	18.5	.4			27.4	12.2
W		5.2	4.8				10.1	10.7
NW		2.0	4.4				6.5	12.1
CALM	.4						.4	.0
TOTAL	2.4	35.8	55.6	6.0			100.0	12.4

MAX WIND — SPEED: 32 KNOTS; DIRECTION: 360 DEG; DAY: 05; HOUR: 18

AUGUST — DATA SUMMARY — 44004

AVERAGE LATITUDE 38.0N — AVERAGE LONGITUDE 070.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	20.2	(27 06)	25.0	27.6	(15 15)	241	31
SEA TEMP (DEG C)	24.1	(01 12)	26.2	28.8	(15 21)	241	31
AIR-SEA TEMP (DEG C)	-05.2	(27 06)	-01.2	C1.4	(28 12)	241	31
PRESSURE (MBAR)	1012.5	(25 21)	1018.8	1028.1	(06 15)	241	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 241

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	5.8	5.8				12.0	10.5
NE	.4	2.5	2.5				5.4	10.4
E		3.7	1.2				5.0	8.0
SE	.8	4.1	5.4				10.4	11.1
S	.4	17.0	10.4	.4			28.2	10.2
SW	1.7	4.6	14.1	.4			20.7	12.4
W	.8	5.0	3.3				9.1	9.0
NW	1.2	6.2	1.2				8.7	7.1
CALM	.4						.4	.0
TOTAL	6.2	48.8	44.0	.8			100.0	10.3

MAX WIND — SPEED: 27 KNOTS; DIRECTION: 170 DEG; DAY: 28; HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 84

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		87.2	12.8						1.4M	2.5M	(28 15)

JULY — DATA SUMMARY — 46001

AVERAGE LATITUDE 56.0N — AVERAGE LONGITUDE 148.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	06.4	(01 03)	09.8	12.8	(15 00)	248	31
SEA TEMP (DEG C)	08.0	(01 21)	10.3	11.6	(28 03)	248	31
AIR-SEA TEMP (DEG C)	-02.6	(01 03)	-00.5	C1.7	(15 00)	248	31
PRESSURE (MBAR)	0988.7	(03 12)	1016.4	1028.6	(20 08)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 248

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		2.0	.8				2.8	8.6
NE	.4	3.6	3.2	2.0			9.3	14.5
E	.4	.8	3.2	1.6			6.0	15.5
SE		3.2	8.1				11.3	12.8
S	.4	5.6	21.8	.8			28.6	13.3
SW		8.5	13.3				21.8	12.6
W	.4	3.2	9.3	.4			13.3	12.8
NW	1.2	2.0	3.2				6.5	10.1
CALM	.4						.4	.0
TOTAL	3.2	28.8	62.9	4.8			100.0	12.8

MAX WIND — SPEED: 31 KNOTS; DIRECTION: 040 DEG; DAY: 28; HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 248

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	2.8	58.1	37.1	2.0					1.8M	3.5M	(30 08)

AUGUST — DATA SUMMARY — 46001

AVERAGE LATITUDE 56.0N — AVERAGE LONGITUDE 148.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.8	(01 15)	11.2	13.1	(12 00)	96	12
SEA TEMP (DEG C)	10.7	(02 15)	11.4	12.4	(12 03)	96	12
AIR-SEA TEMP (DEG C)	-02.3	(01 15)	-00.2	C1.2	(12 00)	96	12
PRESSURE (MBAR)	0998.2	(10 18)	1011.5	1025.8	(01 00)	96	12

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 96

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		13.5	3.1				16.7	8.0
NE	1.0	13.5	15.6				30.2	11.4
E	1.0	8.3	1.0				10.4	7.1
SE	2.1	7.3					9.4	5.4
S	3.1	4.2	5.2	1.0			13.5	10.4
SW	1.0		4.2				5.2	11.4
W	2.1	2.1	2.1				6.3	8.0
NW		5.2	3.1				8.3	8.0
CALM								
TOTAL	10.4	54.2	34.4	1.0			100.0	9.3

MAX WIND — SPEED: 23 KNOTS; DIRECTION: 180 DEG; DAY: 12; HOUR: 12

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 96

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	8.4	74.0	18.7						1.3M	2.0M	(12 21)

JULY — DATA SUMMARY — 46002

AVERAGE LATITUDE 42.5N — AVERAGE LONGITUDE 130.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	12.3	(01 12)	14.8	18.1	(28 21)	245	31
SEA TEMP (DEG C)	14.5	(01 18)	16.1	18.3	(31 00)	248	31
AIR-SEA TEMP (DEG C)	-04.1	(28 15)	-01.2	00.1	(28 21)	245	31
PRESSURE (MBAR)	1016.5	(25 12)	1022.8	1028.4	(08 21)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 246

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	1.6	8.8	41.1	7.3			58.8	15.8
NE	.4	.8	1.2				2.4	10.5
E	.4						.4	2.0
SE								
S								
SW	.4	2.0					2.4	6.8
W	1.2	8.8	1.6				11.8	7.3
NW	.4	8.3	13.4				22.2	11.5
CALM	.8						.8	.0
TOTAL	5.3	30.1	57.3	7.3			100.0	13.3

MAX WIND — SPEED: 24 KNOTS; DIRECTION: 360 DEG; DAY: 20; HOUR: 00

AUGUST — DATA SUMMARY — 46002

AVERAGE LATITUDE 42.5N — AVERAGE LONGITUDE 130.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	14.8	(16 18)	17.1	18.5	(03 03)	241	31
SEA TEMP (DEG C)	17.6	(08 15)	18.1	18.5	(02 00)	240	31
AIR-SEA TEMP (DEG C)	-03.4	(16 18)	-01.0	C0.7	(01 21)	238	31
PRESSURE (MBAR)	0988.5	(24 00)	1020.0	1028.8	(17 21)	242	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 242

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		3.7	31.4				35.1	14.6
NE		.8					.8	4.0
E								
SE		.4					.4	5.0
S		3.7	3.3	.4			7.4	13.0
SW		4.5	8.1	.4			14.0	12.8
W	.4	5.0	10.7	.4			16.5	13.1
NW	1.2	7.0	16.8				25.2	12.0
CALM	.4						.4	.0
TOTAL	2.1	25.2	71.5	1.2			100.0	13.1

MAX WIND — SPEED: 31 KNOTS; DIRECTION: 200 DEG; DAY: 24; HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 211

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		60.7	35.6	3.8					1.7M	3.0M	(29 15)

JULY — DATA SUMMARY — 46003

AVERAGE LATITUDE 52.0N — AVERAGE LONGITUDE 156.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	06.6	(04 12)	08.3	10.9	(30 08)	245	31
SEA TEMP (DEG C)	06.9	(01 06)	08.1	09.7	(21 00)	245	31
AIR-SEA TEMP (DEG C)	-01.0	(15 18)	00.2	01.8	(11 06)	245	31
PRESSURE (MBAR)	0992.1	(04 06)	1013.4	1024.7	(31 21)	245	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 231

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		3.0	5.6	1.3			10.0	13.7
NE		.8	3.5				4.8	14.0
E		.4	1.3				1.7	14.0
SE			4.8				4.8	15.2
S		8.7	18.5	.8			28.0	13.0
SW	.4	5.2	22.1	1.3			29.0	14.5
W		2.6	11.3				13.9	14.1
NW	.4	.4	8.1				8.9	13.4
CALM								
TOTAL	.8	21.2	74.5	3.5			100.0	13.8

MAX WIND — SPEED: 24 KNOTS — DIRECTION: 230 DEG — DAY: 12 — HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 113

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	1.8	43.4	54.9						1.7M	2.5M (13 09)

JULY — DATA SUMMARY — 46005

AVERAGE LATITUDE 46.0N — AVERAGE LONGITUDE 131.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	12.1	(01 12)	14.0	16.7	(31 18)	241	31
SEA TEMP (DEG C)	12.8	(01 12)	14.0	16.4	(31 21)	241	31
AIR-SEA TEMP (DEG C)	-01.8	(13 09)	-00.4	00.6	(28 21)	241	31
PRESSURE (MBAR)	1016.3	(26 12)	1022.9	1028.1	(08 18)	241	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 241

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		4.1	27.0	10.0			41.1	17.4
NE	.4	.4	.4				1.2	8.3
E	.4						.4	2.0
SE								
S	.4	7.1	3.7				11.2	8.7
SW	.8	5.0	.4				6.2	6.2
W	.8	6.6	1.2				8.7	7.0
NW	.8	8.7	19.8	1.2			30.7	12.7
CALM	.4						.4	.0
TOTAL	4.1	33.0	52.7	11.2			100.0	13.2

MAX WIND — SPEED: 26 KNOTS — DIRECTION: 360 DEG — DAY: 22 — HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 241

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	10.8	65.8	21.2	2.5					1.4M	3.0M (23 03)

JULY — DATA SUMMARY — 46006

AVERAGE LATITUDE 41.0N — AVERAGE LONGITUDE 138.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	12.1	(01 06)	15.7	17.6	(28 03)	248	31
SEA TEMP (DEG C)	14.4	(01 15)	16.4	18.0	(28 03)	248	31
AIR-SEA TEMP (DEG C)	-02.4	(20 15)	-00.7	01.5	(08 03)	248	31
PRESSURE (MBAR)	1018.8	(30 12)	1027.8	1037.0	(10 06)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 248

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	6.0	28.0	.4			35.0	13.8
NE		3.8	18.4	.4			22.6	15.3
E		1.2					1.2	8.4
SE								
S	.4	1.6	2.8				4.8	13.3
SW		5.6	8.5				14.1	11.2
W	.8	6.5	3.6				10.9	9.2
NW	.4	6.0	3.2				9.7	8.5
CALM	.8						.8	.0
TOTAL	2.8	28.8	66.5	.8			100.0	12.6

MAX WIND — SPEED: 23 KNOTS — DIRECTION: 040 DEG — DAY: 20 — HOUR: 06

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 248

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	8.5	73.4	16.9	1.2					1.3M	3.0M (30 09)

JULY — DATA SUMMARY — 46008

AVERAGE LATITUDE 57.1N — AVERAGE LONGITUDE 151.7W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.0	(13 06)	09.5	11.4	(27 21)	175	26
SEA TEMP (DEG C)	06.4	(08 21)	07.8	09.2	(31 21)	175	26
AIR-SEA TEMP (DEG C)	00.2	(31 21)	01.7	03.8	(30 03)	175	26
PRESSURE (MBAR)	1003.7	(13 15)	1016.8	1028.2	(30 21)	174	26

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 175

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	3.4	8.7	1.7				14.8	5.8
NE	1.7	8.7	2.3				13.7	7.0
E	1.1	3.4	4.0				8.6	8.2
SE	1.7	9.1	2.3				13.1	7.4
S	1.7	16.6	1.7				20.0	7.0
SW	2.9	10.9	5.7				19.4	8.6
W	3.4	1.7	2.3				7.4	8.1
NW	1.7	.6					2.3	2.3
CALM	.6						.6	.0
TOTAL	18.3	61.7	20.0				100.0	7.2

MAX WIND — SPEED: 18 KNOTS — DIRECTION: 080 DEG — DAY: 17 — HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 146

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	20.5	48.6	27.4	3.4					1.4M	3.0M (30 15)

JULY — DATA SUMMARY — 46009

AVERAGE LATITUDE 60.2N — AVERAGE LONGITUDE 146.8W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.7	(07 12)	10.8	15.4	(31 03)	210	31
SEA TEMP (DEG C)	09.5	(07 08)	11.5	14.9	(31 06)	208	31
AIR-SEA TEMP (DEG C)	-03.4	(11 15)	-00.7	02.4	(31 03)	205	31
PRESSURE (MBAR)	1003.1	(03 06)	1018.4	1030.0	(20 21)	209	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 204

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	7.8	6.4					14.2	3.4
NE	.5	2.9	8.3				11.8	12.1
E	2.9	12.7	14.7				30.4	10.3
SE	5.4	4.4	.5				10.3	4.0
S	5.9	10.8	1.0				17.6	4.2
SW	2.5	2.0					4.4	3.0
W	1.5	1.0					2.5	2.4
NW	1.5	3.9					5.4	4.5
CALM	3.4						3.4	.0
TOTAL	31.4	44.1	24.5				100.0	6.6

MAX WIND — SPEED: 20 KNOTS — DIRECTION: 070 DEG — DAY: 03 — HOUR: 09

JULY — DATA SUMMARY — 41002

AVERAGE LATITUDE 32.3N — AVERAGE LONGITUDE 075.3W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	22.4	(02 09)	25.3	27.3	(12 06)	118	15
SEA TEMP (DEG C)	24.6	(15 12)	26.9	28.9	(01 00)	118	15
AIR-SEA TEMP (DEG C)	-04.5	(02 09)	-01.6	00.4	(09 18)	118	15
PRESSURE (MBAR)	1011.5	(03 21)	1017.4	1021.6	(13 15)	118	15

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 118

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		5.1	2.5				7.6	9.8
NE		.8	14.4				15.3	16.0
E			8.5				8.5	17.2
SE		3.4	.8				4.2	9.2
S	2.5	3.4	10.2	.8			16.9	10.3
SW		5.9	24.6	2.5			33.1	15.3
W		2.5	9.3	.8			12.7	14.3
NW	1.7						1.7	1.5
CALM								
TOTAL	4.2	21.2	70.3	4.2			100.0	13.7

MAX WIND — SPEED: 24 KNOTS — DIRECTION: 180 DEG — DAY: 10 — HOUR: 09

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 118

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	11.9	86.4	1.7						1.1M	2.0M (04 21)

AUGUST — DATA SUMMARY — 46003

AVERAGE LATITUDE 52.0N — AVERAGE LONGITUDE 156.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.3	(02 18)	10.4	12.0	(27 03)	242	31
SEA TEMP (DEG C)	09.2	(07 18)	10.1	11.5	(28 03)	242	31
AIR-SEA TEMP (DEG C)	-01.8	(28 18)	00.2	01.8	(12 03)	242	31
PRESSURE (MBAR)	0993.1	(08 03)	1019.0	1033.0	(22 06)	242	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 24

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	4.2	29.2					33.3	6.6
NE		4.2					4.2	6.0
E								
SE								
S								
SW								
W	8.3	25.0	4.2				37.5	8.0
NW		25.0					25.0	7.5
CALM								
TOTAL	12.5	83.3	4.2				100.0	7.5

MAX WIND — SPEED: 12 KNOTS — DIRECTION: 300 DEG — DAY: 02 — HOUR: 15

AUGUST — DATA SUMMARY — 46005

AVERAGE LATITUDE 46.0N — AVERAGE LONGITUDE 131.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	13.3	(23 15)	15.9	17.1	(03 00)	243	31
SEA TEMP (DEG C)	15.0	(31 18)	16.3	17.3	(03 00)	242	31
AIR-SEA TEMP (DEG C)	-02.8	(23 15)	-00.6	00.8	(28 09)	242	31
PRESSURE (MBAR)	0996.6	(24 12)	1017.7	1028.2	(17 21)	243	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 243

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	1.2	13.6				15.2	14.5
NE		.4						
E							.4	6.0
SE			.8	.4			1.2	18.3
S	.4	5.8	4.1	1.2			11.5	11.0
SW	.4	7.4	8.8	2.1			18.8	11.8
W	.4	5.7	21.8	3.7			30.6	14.6
NW	.4	5.3	14.0	2.1			21.8	13.8
CALM	.4						.4	.0
TOTAL	2.5	23.0	64.2	9.5			100.0	13.8

MAX WIND — SPEED: 31 KNOTS — DIRECTION: 280 DEG — DAY: 25 — HOUR: 12

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	.8	70.4	25.4	3.3					1.6M	3.9M (25 15)

AUGUST — DATA SUMMARY — 46006

AVERAGE LATITUDE 41.0N — AVERAGE LONGITUDE 138.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	15.3	(20 21)	17.5	20.1	(05 21)	248	31
SEA TEMP (DEG C)	17.3	(21 15)	18.4	19.2	(30 00)	248	31
AIR-SEA TEMP (DEG C)	-03.4	(20 21)	-00.9	01.8	(05 21)	248	31
PRESSURE (MBAR)	1008.2	(23 18)	1024.0	1039.8	(18 06)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 246

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		4.5	13.8	.4			18.7	12.5
NE		1.2	1.6				2.8	11.0
E	.4	.4					.8	5.8
SE	1.6	.4					2.0	2.8
S	2.0	1.6	2.0	.4			6.1	8.2
SW	.4	6.9	11.4	.4			18.1	12.1
W	2.4	7.7	17.1	.8			28.0	11.9
NW		2.4	17.9	1.2			21.5	15.8
CALM	.8						.8	.0
TOTAL	7.7	25.2	63.8	3.3			100.0	12.4

MAX WIND — SPEED: 30 KNOTS — DIRECTION: 310 DEG — DAY: 23 — HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 246

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	1.2	78.5	15.7	3.7					1.5M	3.5M (24 06)

AUGUST — DATA SUMMARY — 46008

AVERAGE LATITUDE 57.1N — AVERAGE LONGITUDE 151.7W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	09.6	(01 18)	11.4	13.9	(25 00)	239	31
SEA TEMP (DEG C)	07.3	(21 18)	09.4	11.3	(07 00)	239	31
AIR-SEA TEMP (DEG C)	00.1	(28 06)	02.0	04.4	(03 00)	239	31
PRESSURE (MBAR)	0989.8	(31 06)	1012.4	1025.7	(01 00)	238	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 231

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	3.0	7.4	3.0				13.4	7.9
NE	2.2	9.5	.9				12.6	6.4
E	2.2	5.2	1.3				8.7	7.6
SE	2.6	.4	1.3				4.3	5.5
S	1.7	7.4	1.3				10.4	6.2
SW	3.0	10.4	10.8				24.2	9.8
W	.9	7.4	10.0				18.2	10.4
NW	4.8	2.6					7.4	3.5
CALM	.9						.9	.0
TOTAL	21.2	50.2	28.6				100.0	7.6

MAX WIND — SPEED: 20 KNOTS — DIRECTION: 280 DEG — DAY: 21 — HOUR: 06

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 218

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	14.7	62.4	22.9						1.3M	2.9M (31 09)

AUGUST — DATA SUMMARY — 46009

AVERAGE LATITUDE 60.2N — AVERAGE LONGITUDE 146.8W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	10.8	(18 18)	13.3	17.4	(25 03)	204	31
SEA TEMP (DEG C)	12.5	(23 15)	13.6	15.5	(02 03)	204	31
AIR-SEA TEMP (DEG C)	-03.0	(28 18)	-00.3	03.9	(22 03)	202	31
PRESSURE (MBAR)	0999.0	(31 06)	1013.8	1023.8	(01 00)	203	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 205

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.5	15.1	2.0				17.6	7.7
NE	2.4	2.0	6.8				11.2	10.6
E	2.0	5.4	7.3				14.6	8.2
SE	4.9	8.8					13.7	3.8
S	7.3	9.3					16.6	3.7
SW	6.3	2.4					8.8	2.8
W	1.0	1.5					2.4	3.0
NW	2.4	5.9	4.9				13.2	7.6
CALM	2.0						2.0	.0
TOTAL	28.8	50.2	21.0				100.0	6.4

MAX WIND — SPEED: 18 KNOTS — DIRECTION: 080 DEG — DAY: 08 — HOUR: 00

AUGUST — DATA SUMMARY — 46007

AVERAGE LATITUDE 59.2N — AVERAGE LONGITUDE 152.7W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	09.4	(26 18)	11.8	14.4	(23 03)	98	16
SEA TEMP (DEG C)	09.0	(27 21)	10.5	12.0	(18 09)	98	16
AIR-SEA TEMP (DEG C)	-01.2	(28 18)	01.3	03.9	(23 03)	99	16
PRESSURE (MBAR)	0993.6	(31 00)	1013.0	1021.1	(21 18)	98	16

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 97

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		4.1	1.0				5.2	6.6
NE	1.0	1.0	3.1				5.2	10.8
E		3.1	5.2				8.2	11.6
SE	1.0	11.3	2.1				14.4	7.4
S		12.4					12.4	6.1
SW		4.1					4.1	6.0
W	1.0	14.4	25.8	1.0			42.3	12.0
NW	2.1	6.2					8.2	5.3
CALM								
TOTAL	5.2	56.7	37.1	1.0			100.0	9.4

MAX WIND — SPEED: 22 KNOTS — DIRECTION: 280 DEG — DAY: 22 — HOUR: 12

Table 6
Selected Gale and Wave Observations, North Atlantic
July and August 1978

Vessel	Nationality	Date	Position of Ship Lat. deg.	Position of Ship Long. deg.	Time GMT	Wind Dir. 10°	Wind Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C Air	Temperature °C Sea	Sea Waves+ Period sec.	Sea Waves+ Height ft.	Swell Waves Dir. 10°	Swell Waves Period sec.	Swell Waves Height ft.
NORTH ATLANTIC OCEAN		JULY															
AMER LEADER	AMERICAN	1	43.4 N	43.5 W	00	20	35	10 NM	01	1021.0	21.6	15.6	6	11.5			
SEALAND RESOURCE	AMERICAN	5	41.9 N	60.8 W	06	09	35	.5 NM	63	1009.8	16.7	20.6	5	6.5	09	8	8
ROBERTS BANK	LIBERIAN	5	27.8 N	16.1 W	00	02	M 40	> 25 NM	01	1013.7	20.0	19.0	3	8			
ROBERTS BANK	LIBERIAN	6	32.4 N	14.3 W	00	02	M 38	> 25 NM	01	1019.2	18.5	20.0	2	5			
EXPORT FREEDOM	AMERICAN	6	39.1 N	55.4 W	06	20	40	5 NM	13	1012.5	23.6	23.9	4	10	23	6	14.5
ROBERTS BANK	LIBERIAN	8	41.0 N	10.8 W	00	02	M 37	> 25 NM	01	1023.5	16.2	17.0	3	5	03	7	10
DELAWARE GETTY	AMERICAN	24	25.6 N	85.9 W	06	12	35	2 NM	95	1019.5	26.0		6	5			
BOSTON	AMERICAN	28	17.4 N	72.8 W	18	09	35	10 NM	02	1017.6	29.4	29.4	2	5	09	6	8
SAN JUAN	AMERICAN	29	34.0 N	71.2 W	00	22	35	5 NM	16	1019.0	25.0	28.9	3	6.5	22	6	13
NORTH ATLANTIC OCEAN		AUG.															
MARJORIE LYKES	AMERICAN	4	36.6 N	45.0 W	18	33	35	10 NM	02	1021.0	25.0	25.5	3	5	35	< 6	8
CHOAPA	CHILEAN	13	14.7 N	73.4 W	12	09	35	5 NM	03	1012.4	28.5	28.0	5	6.5	08	8	10
SEALAND GALLOWAY	AMERICAN	15	42.9 N	44.3 W	12	30	35	5 NM	03	1005.1	18.9	21.2	6	5	30	9	8
DALAMAN	TURKISH	15	36.2 N	59.8 W	06	26	35	5 NM	13	1016.2	27.0	26.0	6	8			
NOPAL LANE	LIBERIAN	16	40.8 N	37.9 W	06	24	M 36	5 NM	25	1006.7	21.4	22.0	4	8			
SEALAND GALLOWAY	AMERICAN	16	44.1 N	37.0 W	00	27	35	10 NM	01	1003.4	17.8	17.8	7	13			
EXPORT LEADER	AMERICAN	17	46.7 N	27.6 W	18	22	35	10 NM	02	1003.7	17.2	18.8	3	5	27	8	11.5
SEALAND GALLOWAY	AMERICAN	17	48.3 N	14.7 W	12	16	40	10 NM	01	1018.3	18.7	16.2			21	7	8
EXPORT LEADER	AMERICAN	18	46.3 N	29.9 W	00	29	38	10 NM	02	1008.5	15.6	17.3	3	5	29	8	13
DELTA VENEZUELA	AMERICAN	18	20.5 N	68.8 W	00	11	37	10 NM	03	1016.5	26.1	25.5	4	8	06	< 6	8
YUKON	AMERICAN	22	44.9 N	58.0 W	06	22	35	2 NM	10	1010.5	17.7	18.3		6.5	22	6	10
PVT JOHN R TOWLE	AMERICAN	24	57.6 N	56.7 W	18	05	35	2 NM	41	1004.1	7.8	7.0	5	6.5	05	6	11.5
PVT JOHN R TOWLE	AMERICAN	25	58.9 N	54.8 W	00	05	35	5 NM	41	1004.1	7.8	7.0	5	6.5	05	6	11.5
SAN MARCOS	AMERICAN	28	28.1 N	92.5 W	15	12	45	5 NM	62	1009.1	25.0	32.3	6	11.5	12	12	23
MARCONA CONVEYOR	LIBERIAN	28	27.8 N	91.5 W	18	16	M 35	1 NM	62	1012.8	24.8	30.5	4	8	16	9	11.5
MARCONA CONVEYOR	LIBERIAN	29	28.0 N	92.5 W	00	19	M 36	1 NM	81	1009.3	26.0	30.5	5	8	18	9	11.5
GREAT LAKES VESSELS																	
ELTON HOYT II	AMERICAN	15	47.4 N	89.0 W	06	22	M 36	5 NM	17		17.0	12.0	4	6.5			
JOHN G MUNSON	AMERICAN	16	42.2 N	87.3 W	04	24	M 45	1 NM	97		22.0	23.0		5			
WILLIAM CLAY FORD	AMERICAN	17	45.3 N	83.1 W	12	29	M 36	10 NM	02		14.0	16.0	XX	10			
ERNEST R BREECH	AMERICAN	19	44.1 N	82.5 W	12	20	M 36	5 NM	63		20.0	19.0		5			
ROBERT C STANLEY	AMERICAN	28	45.7 N	83.6 W	06	15	M 35	1 NM	64		18.0			10			

+ Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest windspeed was selected.

WE OF NOAA ARE MAKING USE OF THIS SMALL AMOUNT OF SPACE TO EXTEND OUR THANKS TO ALL THE SHIPS' OFFICERS WHO ROUTINELY TAKE SHIPBOARD WEATHER OBSERVATIONS. TO US, THESE EXCELLENT OBSERVATIONS ARE PRICELESS. WE CERTAINLY DO APPRECIATE RECEIVING THEM ON A REGULAR BASIS.

Table 7

Selected Gale and Wave Observations, North Pacific

July and August 1978

Vessel	Nationality	Date	Position of Ship Lat. deg.	Position of Ship Long. deg.	Time GMT	Wind Dir. 10°	Wind Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C. Air	Temperature °C. Sea	Sea Waves† Period sec.	Sea Waves† Height ft.	Swell Waves Dir. 10°	Swell Waves Period sec.	Swell Waves Height ft.
NORTH PACIFIC OCEAN		JULY															
GREAT OCEAN	JAPANESE	1	46.5 N	176.4 E	17	26	M 35	.5 NM	45	1007.0	10.5	7.0	6	6.5	23	< 6	6.5
ASIA DALE	LIBERIAN	1	53.1 N	161.5 W	03	07	M 35	10 NM	02	1004.0	9.5	12.1	5	8			
VAN WARRIOR	LIBERIAN	1	50.6 N	175.6 W	18	22	35	.5 NM	63	1000.0	11.0	8.0					
MOON RIVER	LIBERIAN	1	26.1 N	148.2 W	01	09	M 35	10 NM	03	1020.1	23.0	27.0			25	< 6	5
ALASKA STANDARD	AMERICAN	2	59.6 N	141.1 W	12	10	35	5 NM	60	1009.1	11.2	13.5	4	6.5			
GREAT OCEAN	JAPANESE	2	46.2 N	172.4 E	05	26	M 35	5 NM	11	1012.5	10.0	9.0	7	10			
VAN WARRIOR	LIBERIAN	2	49.4 N	177.0 E	18	27	40	1 NM	50	1003.0	10.0	8.0					
LAUREL	LIBERIAN	3	50.0 N	137.9 W	00	19	M 38	.5 NM	43	1010.0	13.5	12.0	3	11.5	18	7	11.5
MOBIL ARCTIC	AMERICAN	3	59.2 N	144.5 W	00	09	45	1 NM	10	999.0	9.8	8.8	10	13			
VAN WARRIOR	LIBERIAN	3	49.1 N	175.7 E	00	27	35	1 NM	50	1010.0	12.0	7.0					
ALASKA STANDARD	AMERICAN	3	59.1 N	139.1 W	06	10	35	5 NM	61	1007.6	9.9	13.4	4	5	13	6	8
ARCO JUNEAU	AMERICAN	3	35.8 N	122.1 W	06	32	40	10 NM	00	1015.0	14.4	9.5			32	6	8
VAN TRIUMPH	LIBERIAN	4	50.7 N	168.0 W	12	35	M 40	2 NM	02	1010.0	6.0	7.0					
ARCO JUNEAU	AMERICAN	4	39.7 N	125.4 W	00	34	35	10 NM	02	1014.2	17.8	11.7	3	5	33	< 6	8
MASSACHUSETTS	AMERICAN	5	31.5 N	118.9 W	06	34	35	5 NM	11	1015.5	14.5	13.9	4	6.5			
SEALAND MC LEAN	AMERICAN	5	50.7 N	166.3 W	00	28	35	10 NM	02	1007.0	8.3	6.2	3	6.5			
GLACIER	AMERICAN	5	34.3 N	120.6 W	06	32	M 35	2 NM	07	1013.2	11.7	11.8					
PRES PIERCE	AMERICAN	6	52.7 N	177.0 E	06	22	35	200 YD	40	1008.5	10.7	6.3	2	6.5	22	6	5
ARCO HERITAGE	AMERICAN	6	39.8 N	125.1 W	18	34	40	5 NM	03	1012.5	15.8	12.7	6	10			
GLACIER	AMERICAN	6	38.8 N	126.3 W	18	35	M 38	5 NM	02	1017.6	16.3	15.7	4	6.5			
STAR HONGKONG	BRITISH	7	50.2 N	175.0 E	18	33	36	5 NM	16	1006.5	7.5	5.0	6	8			
ARCO HERITAGE	AMERICAN	7	42.2 N	127.0 W	06	35	35	5 NM	03	1017.3	15.5	17.1	5	10			
HELLESPONT COURAGE	LIBERIAN	8	36.7 N	164.6 E	12	25	M 35	10 NM	02	1020.0	24.0	24.0					
R T ALASKA	AMERICAN	8	39.3 N	125.3 W	18	36	35	5 NM	02	1018.9	15.6	15.5	5	13			
PACIFIC WING	PANAMANIAN	9	52.1 N	173.3 E	12	34	M 40	1 NM	10	1013.5	8.0	6.5	6	14.5			
ASIAN ASSURANCE	LIBERIAN	9	55.0 N	179.8 W	12	36	M 37	< 50 YD	47	999.5	9.3	6.0			36	>13	13
R T ALASKA	AMERICAN	9	39.9 N	125.8 W	00	36	35	5 NM	02	1019.5	18.5	15.5	8	16.5			
ORIENTAL LEADER	LIBERIAN	10	38.0 N	127.5 W	12	34	M 35	5 NM	02	1020.7	16.0	14.0					
EXXON SAN FRANCISCO	AMERICAN	10	38.7 N	123.9 W	18	32	35	5 NM	05	1013.5	13.5	9.5	5	5	32	6	18
ARCO ANCHORAGE	AMERICAN	12	49.4 N	128.0 W	12	36	M 35	10 NM	01	1017.3	16.3	11.1	4	11.5			
ATLANTIC HIGHWAY	LIBERIAN	12	54.2 N	168.5 W	00	23	M 38	200 YD	58	1012.0	10.0	7.0	6	6.5	27	8	6.5
CHEVRON MISSISSIPPI	AMERICAN	12	40.1 N	124.3 W	00	34	35	10 NM	02	1013.9	12.2	8.9	2	5			
SEALAND EXCHANGE	AMERICAN	17	41.0 N	124.8 W	12	32	35	10 NM	02	1015.9	12.8	11.7					
SANTA CLARA	AMERICAN	17	41.4 N	125.0 W	18	36	50	5 NM	07	1013.5	14.4	13.8	7	23			
CHEVRON WASHINGTON	AMERICAN	17	39.4 N	124.1 W	00	31	M 37	> 25 NM	01	1016.3	15.7		6	16.5			
HOEGH MERIT	NORWEGIAN	18	39.7 N	124.4 W	00	34	M 42	5 NM	00	1008.4	15.0	10.5	9	16.5			
SPRUCE	JAPANESE	18	52.8 N	171.7 E	18	31	M 36	.5 NM	41	1002.4	9.0	8.0	7	10	13	7	10
CHEVRON ARIZONA	AMERICAN	18	40.0 N	125.2 W	18	36	35	10 NM	01	1014.2	20.0		3	10	36	6	13
AQUILA	AMERICAN	18	40.8 N	125.7 W	16	34	35	5 NM	05	1013.0	15.0	12.2	5	11.5			
SEALAND COMMERCE	AMERICAN	18	49.3 N	173.0 W	00	35	35	5 NM	51	1004.0	8.8	6.6	6	11.5			
ARCO ANCHORAGE	AMERICAN	19	48.9 N	127.4 W	11	32	M 35	10 NM	01	1021.2	13.4	10.0	6	16.5			
SEALAND COMMERCE	AMERICAN	19	50.0 N	150.7 W	06	19	36	1 NM	50	1021.2	11.7	7.2	4	6.5	18	10	8
ARCO JUNEAU	AMERICAN	20	40.5 N	126.3 W	12	34	M 40	5 NM	03	1013.2	13.0	10.0	3	5			
CHEVRON GENOA	PANAMANIAN	20	17.4 N	151.3 W	06	08	M 36	5 NM	63	1011.0	25.0	26.8	5	10	XX		16.5
EXXON NEW ORLEANS	AMERICAN	20	40.7 N	125.6 W	00	34	35	5 NM	01	1015.0	18.5	11.6	3	5	33	< 6	13
GREEN ECHO	LIBERIAN	21	50.3 N	131.3 W	06	34	M 40	2 NM	41	1021.0	13.0	12.0	12	23			
MOBIL MERIDIAN	AMERICAN	21	50.8 N	130.8 W	18	34	35	5 NM	03	1021.0	14.0	13.4	7	5	33	10	11.5
TOWNSEND CROMWELL	AMERICAN	21	21.2 N	158.4 W	21	08	35	5 NM	02	1011.9	25.1	26.1	4	6.5	12	11	14.5
ARCO JUNEAU	AMERICAN	22	49.8 N	135.9 W	06	04	M 35	5 NM	03	1026.8	13.4	10.0	4	5			
MOBIL MERIDIAN	AMERICAN	22	51.9 N	132.6 W	06	32	50	5 NM	02	1021.3	12.8	12.3	8	6.5	33	10	13
AMER APOLLO	AMERICAN	23	15.6 N	136.8 E	12	26	35	5 NM	60	1004.6	25.6	28.3	3	5			
EXXON BOSTON	AMERICAN	25	21.4 N	109.0 W	18	13	55	10 NM	25	1014.3	26.5	28.9	6	13	12	10	23
PRESIDENT MADISON	AMERICAN	28	27.1 N	123.8 E	12	30	M 35	5 NM	80	995.0	25.6	30.6	5	16.5			
HOEGH MERIT	NORWEGIAN	28	39.5 N	124.3 W	06	33	M 35	10 NM	02	1013.8	15.5						
THOMAS G THOMPSON	AMERICAN	28	51.0 N	145.0 W	18	05	M 35	1 NM	65	1003.5	10.6	10.5	5	8			
VAN ENTERPRISE	LIBERIAN	28	49.7 N	147.3 W	18	36	M 38	.5 NM	61	999.5	13.0	8.0	3	19.5	04	< 6	16.5
ARCO PRUDHOE BAY	AMERICAN	29	50.6 N	136.1 W	06	14	40	.5 NM	62	1008.5	15.0	12.8	4	5	14	8	11.5
GREEN AUKLET	PANAMANIAN	29	50.0 N	146.7 W	00	03	M 35	200 YD		998.0	11.0	12.0		18	03	8	24.5
NEW ENGLAND HUNTER	LIBERIAN	29	44.6 N	149.9 W	00	31	40	10 NM	50	1014.0	14.5	14.0	5	10	32	10	13
THOMAS G THOMPSON	AMERICAN	29	51.0 N	145.0 W	00	03	M 40	.25 NM	63	999.2	10.0	11.2	5	14.5	08	8	19.5
VAN ENTERPRISE	LIBERIAN	29	50.2 N	139.7 W	18	18	M 40	5 NM	05	1004.0	15.5	12.0	5	19.5			
PRES FILLMORE	AMERICAN	29	29.2 N	130.1 E	06	14	42	5 NM	02	995.7	27.3	28.9	6	21	13	6	26
JOHN B WATERMAN	AMERICAN	29	31.9 N	132.2 E	06	11	35	10 NM	01	1003.4	28.9	28.9	6	5	18	8	16.5
SELANDIA	DANISH	30	22.3 N	122.8 E	06	22	M 40	5 NM	02	1000.0	31.0		8	14.5			
AQUILA	AMERICAN	31	41.5 N	126.2 W	18	36	38	10 NM	03	1016.9	17.8	10.6	6	10			
ARCO PRUDHOE BAY	AMERICAN	31	40.7 N	125.8 W	12	36	35	10 NM	02	1019.0	14.5	14.5	3	10			
NORTH PACIFIC OCEAN		AUG.															
ARCTIC TOKYO	LIBERIAN	1	38.3 N	165.2 E	18	17	M 50	50 YD	97	1000.0	21.0	24.0					
CHEVRON LOUISIANA	AMERICAN	1	40.3 N	124.5 W	12	34	M 38	5 NM	02	1011.1	11.1		3	5	33	8	10
ARCTIC TOKYO	LIBERIAN	2	38.0 N	164.6 E	00	25	M 50	200 YD	97	1001.0	23.0	20.0	10	10			
SEALAND EXCHANGE	AMERICAN	2	31.5 N	132.9 E	06	19	36	5 NM	02	999.2	29.4	28.7	4	5	21	8	8
VALOR	PHILIPPINE	4	41.8 N	124.8 W	18	34	M 38	5 NM	00	1018.6	12.0	10.5	6	10			
MELLON	AMERICAN	5	44.2 N	154.8 W	18	18	M 40	2 NM	02	1008.2	14.6	13.2	3	6.5			
ARCO JUNEAU	AMERICAN	5	40.8 N	126.0 W	12	35	M 40	10 NM	02	1019.0	18.0	7.2	3	6.5			
SEALAND COMMERCE	AMERICAN	5	36.4 N	153.1 E	12	29	35	> 25 NM	03	1010.4	27.8	21.7					
VALOR	PHILIPPINE	5	39.8 N	124.3 W	03	34	M 38	5 NM	00	1014.2	13.8	10.0	6	10			
QUEENS WAY BRIDGE	JAPANESE	5	46.4 N	157.1 W	18	19	M 38	200 YD	63	999.6	15.5	11.0	5	10			
JAPAN RAINBOW	JAPANESE	5	45.0 N	158.0 W	18	20	M 45	200 YD	47	1000.0	15.0	14.0	8	16.5			
OGDEN CONGO	LIBERIAN	5	43.5 N	169.0 W	06	22	M 45	1 NM	52	996.1	16.1	13.0	XX	18	22	6	21
ALEUTIAN DEVELOPER	AMERICAN	6	54.6 N	163.4 W	00	07	35	5 NM	02	1002.4	12.2	8.3	3	11.5	08	< 6	14.5
MELLON	AMERICAN	6	42.8 N	155.1 W	00	18	M 40	2 NM	07	1009.2	19.0	18.0	5	10			
VAN WARRIOR	LIBERIAN	6	48.7 N	144.3 W	18	20	40	1 NM	62	1009.0	17.5	15.0					
VAN TRIUMPH	LIBERIAN	6	47.0 N	163.0 W	00	27	M 35	.25 NM		990.0	12.0	12.0					
VAN CONQUEROR	LIBERIAN	6	47.0 N	164.3 W	06	31	M 38	2 NM	02	996.0	10.0	10.0					
FRIENDSHIP	LIBERIAN	6	45.8 N	163.7 E	00	29	M 36	2 NM	02	993.0	13.3	14.0	10	10	31	11	19.5
ORIENTAL SOVERIGN	LIBERIAN	6	49.5 N	162.7 E	00	04	M 42	.25 NM	50	985.0	10.5	11.0	7	13			
CHEVRON ARIZONA	AMERICAN	6	51.0 N	138.4 W	06	23	40	5 NM	02	1008.0	13.2		2	6.5	24	< 6	10

Vessel	Nationality	Date	Position of Ship: Lat. deg.	Position of Ship: Long. deg.	Time GMT	Wind: Dir. 10°	Wind: Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C: Air	Temperature °C: Sea	Sea Waves+: Period sec.	Sea Waves+: Height ft.	Swell Waves: Dir. 10°	Swell Waves: Period sec.	Swell Waves: Height ft.
NORTH PACIFIC OCEAN		AUG.															
JAPAN RAINBOW	JAPANESE	6	44.5 N	157.7 W	00	20	M 48	200 YD	47	1000.0	13.0	13.0	8	13	20	7	16.5
HAKONE MARU	JAPANESE	6	44.4 N	155.1 W	06	21	M 35	2 NM	61	1001.5	16.0	15.0	7	13	24	8	16.5
HOEGH TRANSPORTER	NORWEGIAN	6	43.5 N	149.9 W	18	21	35	2 NM	12	1010.0	17.0	15.0	10	14.5	20	9	21
QUEENS WAY BRIDGE	JAPANESE	6	46.4 N	159.6 W	00	22	M 38	1 NM	60	990.5	13.5	11.5	5	10			
WASHINGTON RAINBOW	JAPANESE	7	49.5 N	179.2 E	00	27	M 40	2 NM	10	998.5	15.0	9.0	6	8	28	12	13
VAN WARRIOR	LIBERIAN	7	48.8 N	145.2 W	00	18	40	1 NM	52	1007.0	17.8	11.0					
JAPAN RAINBOW	JAPANESE	7	41.9 N	146.6 W	18	21	M 35	1 NM	62	1014.0	17.0	15.0	6	6.5	21	7	10
ANNIE JOHNSON	SWEDISH	8	12.4 N	92.2 W	12	08	37	.5 NM	64	1012.5	24.5	27.6					
MASSACHUSETTS	AMERICAN	8	56.3 N	141.6 W	18	13	35	2 NM	50	1009.9	13.4	13.3	2	6.5	18	7	10
PRES JACKSON	AMERICAN	12	22.6 N	125.3 E	06	07	40	2 NM	81	998.0	28.3	26.7	5	8	07	7	13
ORIENTAL EDUCATOR	BRITISH	13	40.2 N	175.6 E	12	15	M 35	1 NM	51	1008.0	21.0	14.0					
SINCERE 3	LIBERIAN	13	44.2 N	173.9 E	12	14	M 40	200 YD		1011.0	13.5	14.5					
SINCERE 3	LIBERIAN	14	44.5 N	177.0 E	00	09	M 53	.25 NM		1009.0	13.0	14.0					
GREAT OCEAN	JAPANESE	14	46.5 N	177.9 W	17	08	M 35	5 NM	51	1001.0	13.0	10.0	7	8			
ARCO SAG RIVER	AMERICAN	15	50.5 N	136.8 W	00	32	M 35	10 NM	01	1019.5	15.7	15.0	5	6.5	30	6	8
VAN WARRIOR	LIBERIAN	15	40.9 N	151.5 E	06	22	35	1 NM	54	1007.0	26.0	18.0					
ASIA DALE	LIBERIAN	19	54.2 N	167.6 W	20	25	40	2 NM	07	1006.0	10.5	10.0	13	19.5			
ALSTER EXPRESS	GERMAN	19	53.4 N	177.6 W	12	27	44	5 NM	02	993.6	10.3	8.9	10	19.5			
OGDEN WILLAMETTE	AMERICAN	19	39.5 N	124.6 W	06	33	35	10 NM	03	1015.2	16.0	13.9	5	11.5			
SEVEN OCEAN	JAPANESE	19	53.6 N	176.5 W	12	27	M 40	5 NM	02	990.5	9.0	10.0	8	13			
GREEN AUKLET	PANAMANIAN	19	52.1 N	168.7 W	18	24	M 34	1 NM	04	1010.5	14.0	8.0	11	29.5			
ASIA HONESTY	LIBERIAN	21	40.0 N	173.2 W	12	14	M 55	10 NM	03	1019.2	22.0	14.0	10	21			
PRES PIERCE	AMERICAN	21	48.9 N	179.9 E	22	15	45	.5 NM	28	995.8	14.0	6.6	6	6.5	15	8	8
PACIFIC WING	PANAMANIAN	21	43.9 N	176.7 W	06	16	M 36	< 50 YD	40	1010.4	17.4	15.5	5	14.5			
ASIA DALE	LIBERIAN	22	52.4 N	171.3 E	09	19	38	10 NM	02	984.5	10.3	11.0	10	16.5			
ASIA HONESTY	LIBERIAN	22	40.0 N	166.9 W	12	14	M 43	10 NM	03	1032.5	23.0	15.0	5	10	14	8	21
SEALAND COMMERCE	AMERICAN	22	49.9 N	172.5 W	06	16	45	.25 NM	45	1017.0	13.9	8.3	6	8	14	10	13
PRES PIERCE	AMERICAN	22	49.5 N	176.1 W	06	15	55	200 YD	45	1007.0	11.5	8.7	3	8	14	13	13
QUINTINA	LIBERIAN	22	47.5 N	177.7 W	00	14	35	.25 NM	47	1012.0	13.5	10.0	5	6.5	14	7	13
IRIS ISLAND	JAPANESE	22	53.1 N	178.5 E	06	13	M 40	.25 NM	41	999.6	11.0	9.0	9	14.5	19	9	14.5
YEH YUNG	CHINESE	23	43.4 N	171.2 E	00	16	M 38	1 NM	51	1000.0	16.5	10.0			12	6	6.5
ARCO PRUDHOE BAY	AMERICAN	25	51.7 N	137.3 W	00	34	M 35	> 25 NM	01	1002.5	16.2	13.5			34	7	10
MATSONIA	AMERICAN	25	20.3 N	156.3 W	06	09	35	10 NM	03	1010.1	25.8	25.0	2	3	09	8	3
ARCO SAG RIVER	AMERICAN	27	49.7 N	130.6 W	12	12	M 35	5 NM	15	1011.0	15.0	15.7					
ARCO JUNEAU	AMERICAN	27	49.4 N	128.2 W	18	13	M 35	5 NM	60	1015.2	15.6	11.2	4	6.5			
GRAND FELICITY	PANAMANIAN	27	49.7 N	129.1 W	18	19	M 45	2 NM	58	1016.0	15.0						
MARGUERITE VENTURE	LIBERIAN	28	13.0 N	139.4 W	00	14	M 35	2 NM	19	1006.0	23.0	29.0			14	8	19.5
ALASKA STANDARD	AMERICAN	30	59.2 N	142.5 W	12	09	35	5 NM	81	1000.3	14.5	17.0	6	10			
SEATRAIN CONCORD	FRENCH	30	32.1 N	130.6 E	18	25	M 38	5 NM	18	1005.5	27.0	28.5	4	10			
ORIENTAL EDUCATOR	BRITISH	30	28.4 N	128.4 E	12	04	M 36	2 NM	02	996.2	27.7	22.0					
EVER SUMMIT	PANAMANIAN	30	24.0 N	129.5 E	18	23	M 35	2 NM	52	995.2	25.0	28.0					
MEDITERRANEAN CARRIER	BRITISH	30	41.8 N	164.0 W	18	27	35	10 NM	02	1018.0	23.2	16.0	4	5	27	8	11.5
PRES POLK	AMERICAN	31	29.2 N	135.1 E	06	20	35	5 NM	02	1000.0	27.5	27.8	5	10	20	< 6	14.5

+ Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest windspeed was selected.

(Continued from page 37.)

This was about the time that Faye showed up just east of Guam and within a day of the birth of tropical storm Gloria about 400 mi east of Luzon. Both of these storms took a northerly course. The PRIBOY was run over by Faye early on the 29th and suffered 43-kn easterlies in 23-ft seas. Upon nearing the 20th parallel, Faye turned a clockwise loop as the month came to a close, while Gloria brushed the northern Ryukyu Islands with her 40-kn winds. On the 30th and 31st the EVER SUMMIT, ORIENTAL EDUCATOR, and PRESIDENT POLK all felt Gloria's gale-force winds. The PRESIDENT POLK reported 15-ft waves. Gloria fell apart off the coast of Kyushu, while Faye reached typhoon strength on the 1st. As Faye was accelerating northwestward, satellites picked up tropical storm Hester, a late bloomer, near 31°N, 150°E, on the 30th. Hester was moving northeastward and generating 45-kn winds. By the 1st he was becoming extratropical near 45°N, 170°E. This was when Faye was just turning it on. By the 3d her winds climbed to 110 kn as she passed 100 mi southwest of Iwo Jima on a collision course with Japan. However, Japan was spared when Faye turned sharply toward the east-northeast and began to weaken as she crossed the 30th parallel on the 5th. The following day the NOJIMA just south of the center survived 43-kn winds in 26-ft seas. By the 7th Faye was a weakening tropical storm and fast becoming extratropical.

Casualties--The 4,743-ton cargo vessel EURCO LINK reported heavy weather damage that occurred between Acajulta and Cristobal on the 13th. The 7,189-ton HOWELL LYKES arrived Manila on the 27th with reportedly heavy weather damage that occurred while enroute from Hong Kong. Tropical storm Elaine was in the area at the time.

Rough Log, North Atlantic Weather

October and November 1978

ROUGH LOG, OCTOBER 1978--This month there are three primary climatological storm tracks according to the U.S. Navy Marine Climatic Atlas of the World - North Atlantic Ocean. The northernmost one comes out of Canada and turns northward over Labrador into Baffin Bay. The center one originates over the U.S. East Coast, crosses Newfoundland, and moves on to Iceland and the Greenland Sea. The southern track begins off the U.S. Coast near 40°N, 55°W, and proceeds northeastward to the Faeroe Islands and Norway. The actual mean tracks this month followed the gross climatic pattern. The northern track into the Baffin Bay was farther north than normal--Hudson Bay to Resolution Island and into Baffin Bay. The central track came across southern Canada to the Strait of Belle Isle to the Denmark Strait and into northern Norway. The southern track originated off Cape Hatteras and moved eastward prior to turning northeastward and stopping south of Iceland.

Storms usually do not cross the Greenland Icecap and survive, but this month five storms made it. One storm that originated near St. John's crossed the normal traffic flow on a southeasterly course, made a large clockwise loop, and ended less than 500 mi from its starting point.

This month the mean pressure pattern had radical differences from the climatic version. There were three low-pressure centers between 60° and 70°N from Baffin Bay to the eastern Barents Sea. The deepest Low was 996 mb near the southern tip of Novaya Zemlya. A 1002-mb Low was near the climatic position of the Icelandic Low between Greenland and Iceland. The third Low was also 1002 mb over southern Baffin Bay. The first and third Lows were anomalous according to climatology.

The major high-pressure center was located over the Brest Peninsula of France at 1024 mb. This center was an extension of a long, narrow ridge that stretched westward along 45°N from a 1029-mb center over Siberia. A 1019-mb high-pressure center that corresponded to the climatic center was near 30°N, 50°W, or 20° longitude west of its normal position.

This shifting of the pressure centers resulted in four significant anomaly centers. The largest was a minus 11 mb over the southern Barents Sea. Next was a positive 10-mb center off the Irish coast. A minus 7-mb center was over the Greenland Icecap, and another minus 3-mb center was near 33°N, 31°W, or near where the Azores High would normally be centered.

The mean upper air flow at 700 mb was much closer to the normal climatic pattern. A Low was centered near Ellesmere Island with another near Novaya Zemlya. This last center was shifted from its normal position near Severnaya Zemlya. There was a trough over the eastern United States with an anomalous shortwave trough slightly west of the Azores Island and another over the central Mediterranean Sea. These latter two troughs produced an anomalous ridge over the Bay of Biscay.

The month produced three tropical cyclones--tropical storms Irma and Juliet and hurricane Kendra.

Extratropical Cyclones--The first storm of the month formed southeast of Wilmington, N.C., on the first day of the month. By late on the 3d the storm was gaining strength rapidly. The MARINE ATLANTICA was in Cabot Strait with 45-kn northwesterly winds. Other ships were getting up to 40-kn gales. At 0000 on the 4th, the BEN OCEAN LANCER was north of Trinity Bay with a 60-kn northeaster and 23-ft seas. By 1200 the 984-mb storm was near 52°N, 39°W (fig. 42). The HOQT reported the highest wind of 60 kn west of the center. The WORLD SPLENDOR had 50-kn winds and 33-ft waves, while the SUGAR REFINER sustained 55-kn winds and 23-ft waves, all in the northwest quadrant. On the 5th the CRYOS was in the southwest quadrant (44°N, 45°W) with 45-kn northwesterlies and 20-ft seas.

There was a string of five LOWs in an arc from northern Norway to near 55°N, 35°W, and southward to tropical storm Irma--the fifth LOW. A 1034-mb HIGH was sitting over the Bay of Biscay. This was

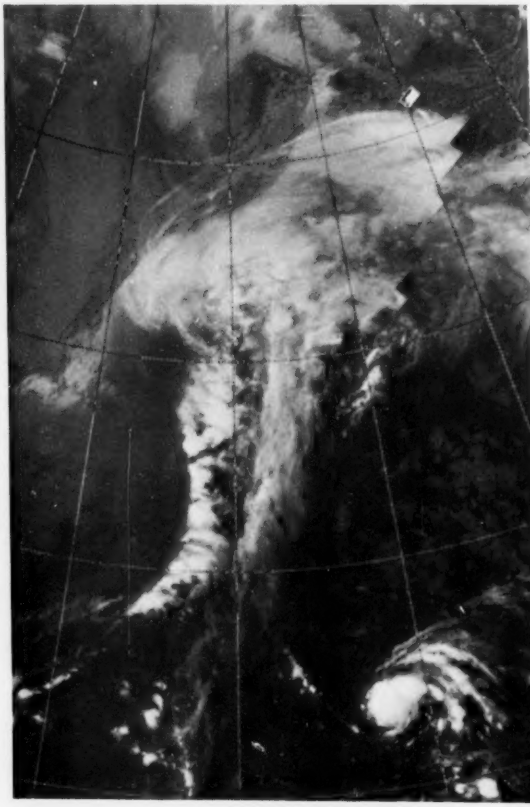

Figure 42.--Upper air clouds obscure the surface low-pressure center. The eastern north-south cloud band is associated with the surface front, while the western band is with the upper air trough. Tropical storm Irma is approaching the Azores.

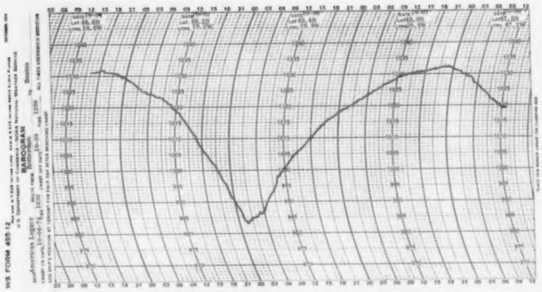

Figure 43.--The barogram of the AMERICAN LEGACY indicates her passage through the LOW.

one of the five LOWs, but later on the 5th it disappeared, and another took its place. The AMERICAN LEGACY passed through the LOW that developed and registered a pressure of 984 mb (fig. 43). Her winds at 1200 on the 6th were 45 kn and were 40 kn for the next 12 hr. The seas did not build very high, but the swells were 23 ft.

This was the LOW that took the place of the one above. It had been analyzed on the 0000 chart of the 5th south of the first storm. Tropical storm Irma was over the Azores and moving northward. Ships in the vicinity were reporting gales. By the 0000 chart of the 6th, Irma had blended into the overall cyclonic circulation of the extratropical LOW. Ocean Weather Stations Charlie and Lima measured 35- to 40-kn winds and seas to 20 ft. The EHIME MARU was in the far southwest quadrant (37°N, 43°W) and reported 41-ft swells. By 1200 the 990-mb storm was near 51°N, 24°W. The AMERICAN LEGACY, OSCO SIERRA, and the PETRODVORETS had 45- to 50-kn winds with seas and swells up to 23 ft. The OSCO SIERRA coded the seas as 30 (49 ft). At 1800 the FRANKFURT was within 5 mb of the center (52°N, 25°W) with 64-kn winds and swells of 39 ft. OWS Romeo reported 25-ft seas. On the 7th the winds seemed to decrease, but many ships were battling 20- to 25-ft seas and swells. One ship just west of the center found 55-kn winds.

By 1200 on the 8th the central pressure of the storm was still only 992 mb, but there was a tight gradient between it and a 1034-mb HIGH over the central ocean. Both systems were very elongated in the north-south direction. The FRANKFURT (54°N, 14°W) was pounded by 52-kn winds and 30-ft waves. The ANCO SOVEREIGN at 46°N, 25°W, was slammed by 33-ft waves. Other ships were battered by waves in the 30-ft category, mostly in the area of long fetch on the western side (fig. 44).

On the 9th the storm moved north of Scotland and weakened, but a second LOW had formed off Portugal, which helped retain the tight gradient and long fetch on the east side of the HIGH. Four ships still had winds over 50 kn. The HOQT (for which no name could be found) was faithfully reporting each 6 hr. She had 34-ft seas and swells. The RIGG at 53°N, 13°W (in the same boat as far as a name was concerned) was battered by 39-ft swells and 33-ft seas. The storm dissipated on the 10th.

This LOW came out of the Dakotas and swung across the Great Lakes. As it moved across Quebec, its

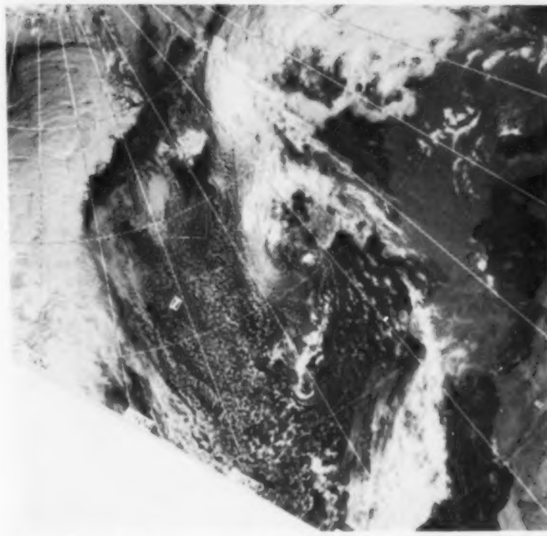

Figure 44.--The apparent low-pressure center is near 52°N, 16°W. The north-south elongated circulation is indicated in the more solid cloud bands. The long fetch is beneath the cumulus clouds south of Iceland, which for a change is clearly visible. The heavy clouds on the left have piled up against the west side of the HIGH.

southerly circulation came up against that stubborn HIGH over the central ocean, which was mentioned above. The gradient close to the center itself was lax, but it was very strong east of the front. On the 8th the storm was near Frobisher Bay at 992 mb. The BAKKAFOS was on the Labrador Sea off Hamilton Inlet with 58-kn south-southeasterly winds. On the 9th the OXSQ near Sondre Stromfjord fought 52-kn southerly winds. Later in the day the PAMIUT near Frederickshab had 60-kn southeasterly winds that paralleled the rugged coast. Late that day the storm died over Melville Bay.

Several waterspouts were spotted the morning of the 10th near New Brunswick, Ga.

This LOW popped up over Newfoundland in the trough of one of the storms that crossed the Icecap. It was also the one that cut across the main northeasterly track. The HIGH had suddenly broken down on the 10th, and this LOW was picked up on the 11th. By 1800 on the 11th, the ANCO SOVERNEIGN had made it to 42°N, 49°W, and now had 52-kn northwesterly winds and 36-ft swells with this storm. At 1200 on the 12th, the LOW was 994 mb near 44°N, 35°W (fig. 45). Six ships in the general area of 39°N, 43°W, reported 40- to 54-kn winds. Two of them, the C.V. STAGHOUND and POSSEHL, had 30-ft seas or swells. On the 13th the ANCO ENDEAVOUR and LINGUIST had winds of around 50 kn and waves to 34 ft. These continued all through the day. On the 14th the HOLLANDIA (41°N, 38°W) had 55-kn northeasterlies in the northwest quadrant. The waves were 20 ft. The ORBITA about 400 mi west of the center had 33-ft swells. On the 15th

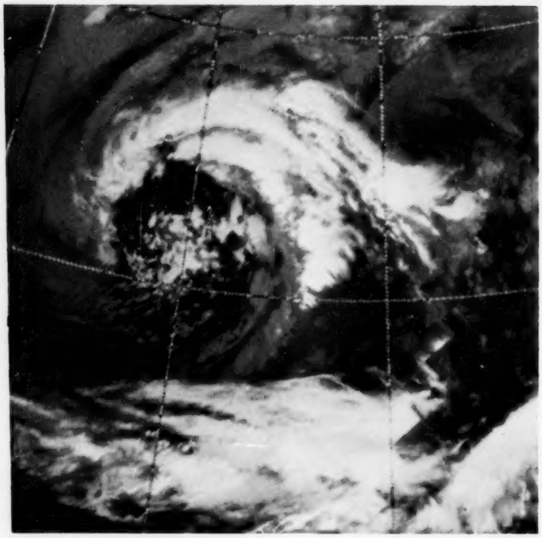

Figure 45.--This infrared image was taken 9 hr earlier at 0300. The storm was still west of 40°W at that time.

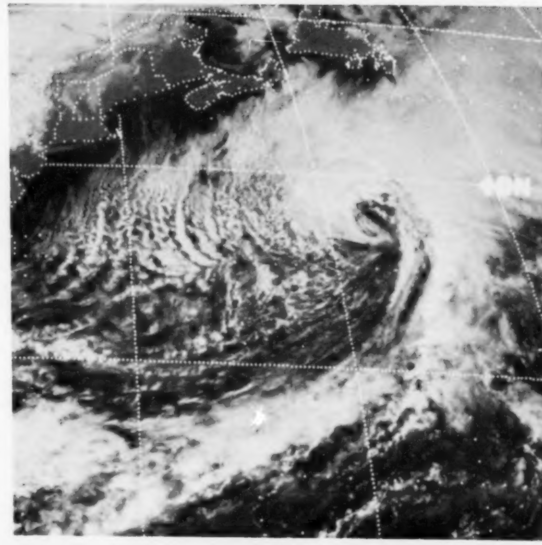

Figure 46.--The NOAA geostationary satellite pinpointed the storm at 1700. The comma-shaped cloud northwest of the center indicates an area of large vorticity advection, which translates into high winds and turbulence. The cloud streaks to the west indicate further instability from cold air over warm water.

the 33-ft swells were transferred to the ALMUT BORNHOFEN near 38°N, 45°W. The stronger winds and the higher waves were now north of the storm as high pressure to the northwest moved eastward. On the 16th the storm started turning northward after having moved southward then westward. The storm was weakening rapidly, and it disappeared on the 18th.

This storm formed in the lee of the Rocky Mountains of Canada. It traveled southeastward and crossed Cape Hatteras around noon on the 16th. Off Cape Hatteras it started to spin up and at 0000 on the 18th was 1000 mb near 37°N, 62°W. Prior to this on the 17th, the CHEVRON MADRID (37°N, 68°W) found 56-kn northerly winds and 20-ft seas. The Coast Guard cutter VIGOROUS was near Nantucket Island with 62 kn from the north. On the 18th three ships near 38°N, 65°W, had winds from 44 to 52 kn and waves to 20 ft. At 1800 (fig. 46) the LINDO at 38°N, 60°W, had 60-kn northerly winds and 23-ft waves striking her port beam. The DEFIANCE was sailing south of the storm at 1930 with a minimum pressure of 994 mb (fig. 47). At 1800 she had had 40-kn gales with squalls, and at 0000 on the 19th she had 41 kn with 16-ft waves. The 984-mb storm was near 45°N, 48°W, at 1200 on the 19th. The BARWA east of the center had gentle 45-kn gales, but she was battered by 25-ft seas and 33-ft swells. Winds in the 40-kn and waves in the 20-ft categories continued.

By the 21st the storm was 968 mb on the southeast coast of Greenland. The DORDRECHT was about 150 mi south of the center east of Kap Farvel with 60-kn winds and 30-ft seas on her stern. On the 22d this LOW was absorbed by another coming in from the west. High winds and seas continued through the day, but gradually decreased.

A LOW that moved eastward from the U.S. East Coast dissipated, and this LOW formed in the broad trough

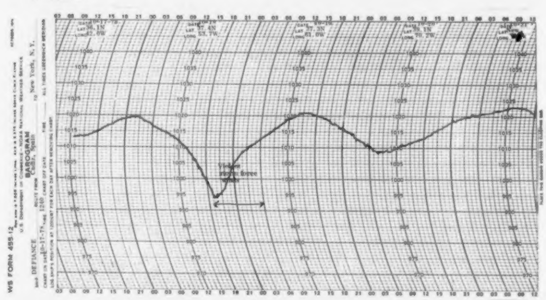

Figure 47.--The DEFIANCE was within 1 to 3 mb of the center of the storm at 1930. Thanks to the New York Port Meteorological Officer for obtaining these copies of the barograms from the ships.

near 40°N, 45°W, on the 24th. The ECKERT OLDENDORFF was near the new center and found 23-ft swells from the old circulation. By 1200 on the 26th, the LOW was still small in area, but the pressure was now 988 mb. The AMERICAN ARGOSY had sailed almost directly into its center with 990-mb pressure, 40-kn westerly winds, and 15-ft waves. On the 27th a Soviet ship was southwest of the center and found 45-kn northwesterly winds with 36-ft waves. Other ships were reporting 20- to 25-ft swell waves. The storm was on a northeasterly track; it was absorbed by a stronger system on the 29th.

A frontal wave was the start of this vicious storm. In less than 24 hr it had consolidated into an intense circulation. A French ship was off St. John's with 44-kn southerly winds on the 28th. At 1200 the ATLANTIC SAGA was 350 mi southeast of the 972-mb center with

45-kn winds and 33-ft seas; by 1800 the seas had dropped to 26 ft. The MANCHESTER CONCORDE at 53°N, 49°W, was fighting 52-kn winds and 23-ft waves. On the 29th her sister ship, the MANCHESTER COURAGE, was sailing eastward in the opposite direction with 43-kn winds and 23-ft seas. OWS Charlie was on station with 16-ft seas and 23-ft swells.

Winds of 40 to 50 kn and waves to 25 ft continued into the 30th. At 1200 the MERCANDIAN CLIPPER (60°N, 29°W) had 60-kn westerly winds. Icelandic fishing boats were buffeted by persistent winds over 40 kn. On the 31st the LOW became stationary near 65°N, 35°W, until November 3, when it finally dissipated.

This frontal wave formed in the southern part of the col area between two HIGHs on the 30th near 39°N, 52°W. It was a well-formed storm 24 hr later, and strong gale-force winds were already blowing by 1200 on the 31st. The BOOKER VANGUARD was 450 mi to the east with 23-ft swell waves. The wind barb could not be read because of the analysis. The ZEALANDIC (48°N, 33°W) was ravaged by 60-kn northerly winds with a pressure of 994 mb. She was less than 100 mi from the 990-mb center at 1800. The USNS METEOR was passed by the storm near 49°N, 31°W, where she recorded a minimum pressure of 987 mb. Early on November 1 six ships along 50°N on both sides of the storm radioed winds between 40 and 50 kn. The highest waves were 25 ft reported by the GENE TREFETHEN at 51°N, 29°W. By 1200 the LOW had disappeared.

Tropical Cyclones--Tropical storm Irma developed from a low-pressure system of subtropical origin, which formed about 500 mi south of the Azores on October 2. Convection gradually increased around the LOW as it drifted northward during the following 2 days (fig. 48). On the 5th Irma turned toward the north-northeast and passed about midway between the westernmost islands of Corvo and Flores and the group of larger islands of the central Azores. Of the few observations received from the Azores during this period, no winds of gale force were reported, but a few ships reported sustained 40-kn winds well east of the center in an area of strong pressure gradient between Irma and a HIGH to the northeast. As Irma passed north of the Azores, she was overtaken and absorbed by a strong frontal system and gradually lost her identity on the 5th.

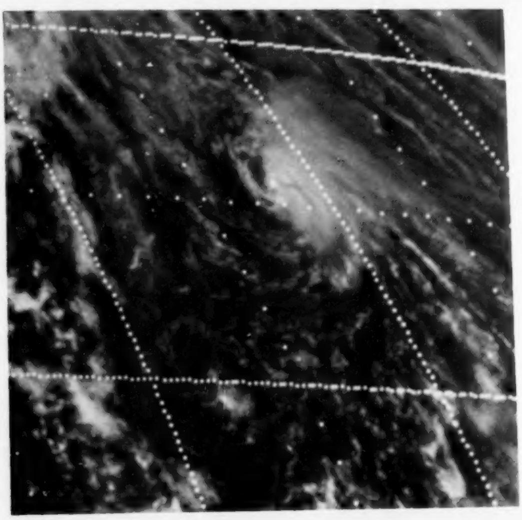

Figure 48.--Tropical storm Irma is about 150 mi south of the Azores at 1700 on the 4th. The northern limit of her clouds have reached the islands.

At midday on the 7th, low-level cloud lines and a few ship reports indicated that a closed circulation was forming at the surface about 600 mi east of San Juan, Puerto Rico. The system was classified as a tropical depression at 1800. Postanalysis indicates that storm strength was reached at 1200 on the 8th at a position 400 mi east-northeast of San Juan. The depression was named tropical storm Juliet on the 9th. Juliet gradually recurved during the next several days in response to a short-wave trough which moved eastward from the southeastern United States. A gradual acceleration to a 20-kn forward speed accompanied this recurvature, and strong westerlies aloft were encountered at more northern latitudes. The storm passed 150 mi north of San Juan on the 9th and was last located 300 mi southwest of Bermuda at 1200 on the 11th, before becoming absorbed by a developing extratropical low-pressure system. Maximum sustained winds of 45 kn and a minimum sea-level pressure of 1006 mb were reached on the 9th, and this intensity was maintained for most of Juliet's existence (fig. 49).

Hurricane Kendra originated in an area of interaction between an old frontal zone which had moved southward to an east-west orientation across the southwestern Atlantic along latitude 25°N on the 25th and a tropical wave that had moved off the African coast on the 15th. During the development period a low-level

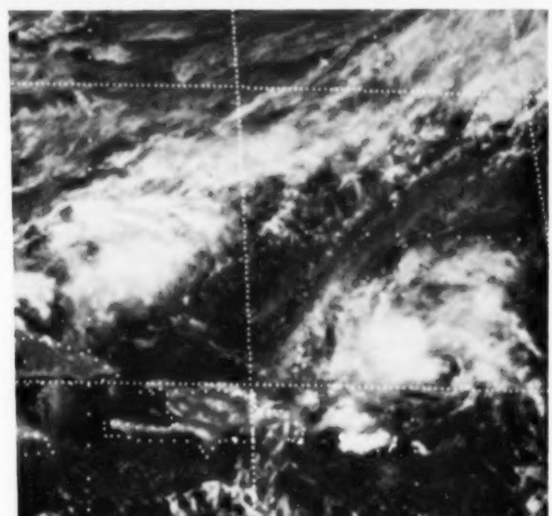

Figure 49.--Tropical storm Juliet never became well organized. In this midday image on the 9th, she is north of Puerto Rico and appears to be a mass of convective activity. Surface observations verified her cyclonic nature.

flow of moisture-laden air, accompanied by widespread cloudiness and precipitation, persisted over the eastern Caribbean, the Lesser Antilles, and Puerto Rico. Heavy rain fell over Puerto Rico from the 22d through the 27th. Some stations on the island measured over 18 in, and there were numerous reports of 10 to 15 in during the 6-day period.

The disturbed weather in the Caribbean shifted northwestward as satellite pictures showed an area of very concentrated convection north of Hispaniola during the night of the 27th. On the 28th a depression developed just east of the easternmost Bahamas. The system became better organized and was upgraded to a tropical storm at 1000 on the 29th. The Crowley Towing Company ship SEA RACER, near 24°N, 73°W, encountered winds of 60 to 70 kn and a sea-level pressure of 999 mb during the evening of the 28th. Kendra continued to develop on the 29th and was upgraded to a hurricane after an Air Force reconnaissance plane reported surface winds of 70 kn during the afternoon (fig. 50).

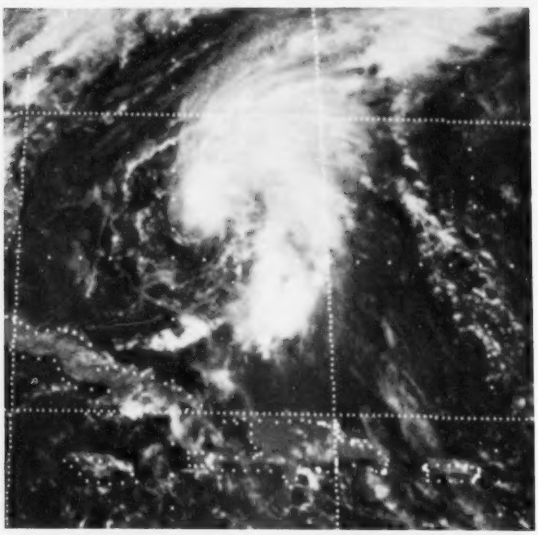

Figure 50.--It was about this time that a reconnaissance aircraft verified that Kendra had 70-kn winds as reported earlier by the SEA RACER.

There was little change in strength during the next 24 hr as the hurricane moved north-northeastward at 8 to 10 kn. Gale warnings were posted south of Cape Hatteras, and 25- to 35-kn winds occurred offshore from Delaware Bay to north Florida. High tides and heavy surf caused some beach erosion. By late afternoon on the 30th, Kendra began to weaken. She was downgraded to a tropical storm during the evening of the 31st. By 0400 on November 1, surface winds had decreased to less than gale force, and all tropical structure was gone, although a closed surface low of 1008 mb persisted as the system began to accelerate northeastward. That afternoon the LOW deepened somewhat under the influence of a strong midtropospheric trough moving off the U.S. East Coast.

By 1200 on November 2, extratropical Kendra had raced eastward to 43°N, 44°W, and had deepened to 992 mb. At 0600 the NOVO MESTO had reported 72-kn winds as the storm moved nearly over her position. At 1200 the winds were only 48 kn. The PRIMORSK had 54-kn southeasterly winds with 25-ft swell waves in the southeast quadrant. At 1800 the FURUNES at 44°N, 37°W, found 63-kn southerly winds as the storm approached. The AMERICAN ACCORD (fig. 51) passed within a degree of latitude of the center at 0000 on the 3d with 989 mb on her barograph. About 24 hr later she encountered a frontal wave with 993 mb. (The New York PMO sent a copy of the barogram, but we did not obtain a copy of the observation form.) The storm began to weaken on the 3d, and it disappeared from the analysis early on the 4th.

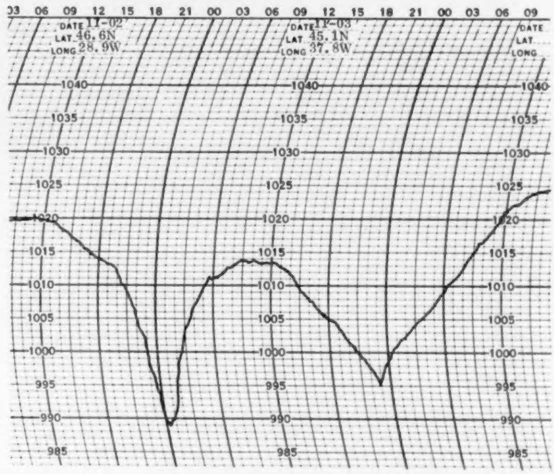

Figure 51.--The AMERICAN ACCORD moved from one station to another within 24 hr. The frontal wave did not appear as severe as the first storm.

Casualties--The 30,408-ton Greek tanker CHRISTOS BITAS (fig. 52) ran aground 4.5 mi east of Smalls Lighthouse (51.7°N, 05.7°W) on the 12th. The vessel developed a heavy list and was in danger of sinking. Pumps were placed aboard to lighten the cargo, but lightering was delayed by bad weather, winds up to 35 kn, and seas to 15 ft. Over 35,000 tons of oil were transferred to the tanker BRITISH DRAGOON by the 22d. The owners decided to scuttle the ship, and on the 31st she was sunk in 2,600 fathoms, approximately 300 mi west of Fastnet Rock.

The 424-ton German VAGABUND and the 4,185-ton Polish ZAMBROW collided in fog in the Kiel Canal on the 14th. The American dredger GEORGE A. MCWILLIAMS sank in heavy seas in Breton Sound in the Mississippi River Gulf on the 15th. All of the crew were rescued with none injured.

The 4,892-ton Norwegian GOLAR BORG sustained a serious list in heavy weather on the 31st while about 675 mi west of the Azores. Twenty-two of the 26 crewmembers were picked up by the HARDANGER. The vessel was reported on her side with starboard side up in heavy seas. Later, she could not be found. The CANMAR SUPPLIER IV (1,190 tons) encountered ice at Tuktoyaktuk, Northwest Territories, on the 30th, which caused the flooding of a double-bottom tank.

Figure 52.--The stricken tanker CRISTO BITAS is listing to starboard with the sea over her freeboard. Oil is being transferred to the ESSO YORK tied alongside to lighten the BITAS. Wide World Photo.

ROUGH LOG, NOVEMBER 1978--The storm tracks this month were fewer than normal and widely dispersed. There was no favorite path. The tracks were spread from 75°N over the Greenland Sea to 25°N off the coast of the United States to 20°N off the West Indies. Climatology shows primary tracks across the Great Lakes and Maritime Provinces and into the Labrador Sea, and from off the east coast of the United States to across Iceland and into the northern seas.

The monthly mean sea-level pressure was also quite different from climatology, especially in central pressures. The Icelandic Low had its principal center at 991 mb near the climatic position at 62°N, 30°W, but it was 12 mb deeper. There were two secondary Lows stretching northeastward--a 993-mb center between Norway and Spitsbergen and a 994-mb center over Nova Zemlya. This produced a large negative anomaly area over the polar region. There was a minus 13-mb area south of the Denmark Strait and a minus 17-mb area over the Kara Sea.

The Azores High, which is normally 1019 mb near 35°N, 30°W, was completely overshadowed by a 1030-mb center over Hungary. The pressure over the eastern United States was also higher than normal. This higher pressure resulted in positive anomalies over most of the Northern Hemisphere middle latitudes. A large plus 14-mb area was over western Europe. This positive area stretched from the Shetland Islands south across the Sahara Desert. A positive anomaly area stretched from a 4-mb center over New England to a 12-mb center west of Vancouver Island.

The upper air pattern and wind flow at 700 mb differed mainly in central heights. The Low over Baffin Island was 122 m deeper than the climatic normal. Across the midlatitudes the pressure surface ranged from 60 m higher over Virginia to 117 m higher over Germany. Over the North Atlantic the winds were mainly zonal with no sharp trough. It would be difficult to precisely locate the long-wave trough.

There were no tropical cyclones this month. For the season there was a total of 11 tropical cyclones, six tropical storms -- Amelia, Bess, Debra, Hope, Irma, and Juliet -- and five hurricanes -- Cora, Ella, Flossie, Greta, and Kendra. This was the largest total number of tropical cyclones since 1971. The annual average for the past 30 yr is four tropical storms and six hurricanes for a total of 10.

Extratropical Cyclones--This was a strong storm as it moved across the Northwest Territories of Canada laying down a blanket of snow. Late on the 2d it crossed over the Labrador Sea and picked up additional moisture. At 1200 on the 3d, the 980-mb LOW was near 56°N, 47°W. A Soviet ship 400 mi south of the center fought 56-kn winds and 20-ft seas. The KURDISTAN (59°N, 28°W) reported only 40-kn winds, but the swell waves had built to 26 ft with the long fetch. On the 4th the LOW was traveling northeastward over Iceland and bringing gale-force winds to ships in the Norwegian Sea. On the 6th it died over the Greenland Sea.

As the storm above turned toward Iceland, a frontal wave developed near 50°N. The circulation exploded and within 12 hr it was 984 mb near 48°N, 29°W (fig. 53). A Navy ship was west of the center with 60-kn northeasterly winds and 31-ft waves. The CETRA CARINA was east of the front with 50-kn winds out of the south in squalls. The SUGAR TRANSPORTER was fighting 23-ft waves and 30-ft swells near 46°N, 41°W. On the 5th the GXXZ had 60-kn easterly winds with 25-ft waves slightly north of the storm's center. Ocean Weather Station Romeo was holding on station with 23-ft waves. On the 6th the POLYARNYY KRUG (59°N, 24°W) had 33-ft swells pounding her starboard quarter.

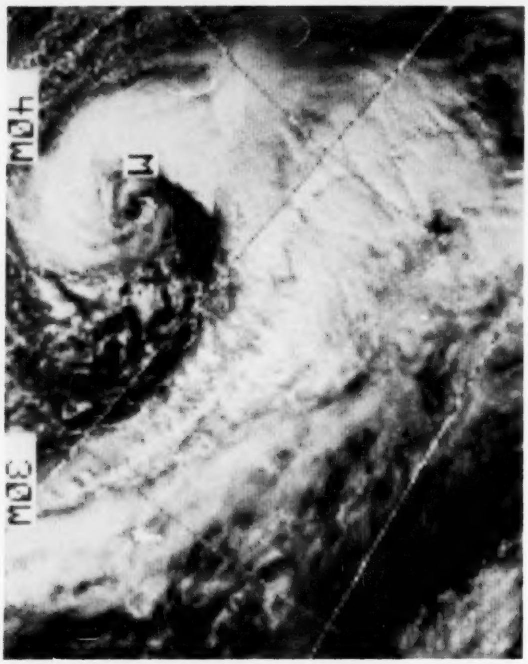

Figure 53.--At about noon on the 4th, the storm was near 46°N, 34°W, according to the DMSP image.

A strong storm moved across northern Hudson Bay on the 3d, but it broke up on the Greenland Icecap on the 5th. Another center formed near Kap Farvel late that day. Late on the 6th and early on the 7th, the PAULA HOWALDT RUSS was near 57°N, 40°W, with 50-kn winds and 23-ft seas. To the south OWS Charlie was contending with 21-ft swells. At 1800 the C. P. VOYAGEUR and the RIGG were south and west of Ireland with waves running 25 to 30 ft and winds blowing up to 53 kn. Twelve hours later the RIGG's radio report indicated 36-ft swells. This LOW became stationary over northwestern Iceland on the 7th (fig. 54) and disappeared on the 8th.

At this time another LOW moved across the Labrador Sea. It also vanished over the Icecap with another LOW forming east of Kap Farvel. At 1200 on the 8th, the INDIGUIRKA near 59°N, 39°W, reported westerly winds of 47 kn with seas of 26 ft.

Figure 54.--The surface LOW had moved north of the upper air LOW, which is portrayed in this DMSP image.

A high-pressure center had been holding firm over the Balkans and the gradient over the North and Norwegian Seas tightened. The weather station at Molde, Norway, on the coast, measured 50-kn winds on the 9th. A SHIP at 60°N, 34°W, was sailing westward into 44-kn winds, 20-ft seas, and 30-ft swells. The RO near Nordkapp was battling 49-kn winds and 26-ft seas. On the 10th this LOW also disappeared.

This storm began in the vicinity of Reindeer Lake in central Canada. On the 9th it crossed the Labrador coast south of Cape Chidley. As previous storms had done, it dissipated over the Greenland Icecap, and a new center formed east of Kap Farvel. A SHIP near 55°N, 40°W, had 44-kn gales accompanied by 16-ft seas just prior to passage of the front on the 10th. The BRUARFOSS (58°N, 44°W) was west of the front with 40-kn winds and 30-ft seas. At 1200 on the 11th, the

974-mb storm was over the Denmark Strait. OWS Lima measured 40-kn gales with 20-ft seas, and Mike had 43 kn with 21 ft. The OGDEN FRASER was crashing into 30-ft swells.

On the 12th the LOW retrograded southwestward, and the winds and seas to the south began to increase. Charlie had 23-ft seas and 26-ft swells with 45-kn winds. A Soviet ship was near 70°N, 15°E, with 43-kn southwesterly winds and 28-ft waves. The RO was in the same vicinity (71°N, 19°E) and reported 39-ft waves. There were many reports in the North and Norwegian Seas of 40- to 50-kn winds and waves to 25 ft. On the 13th and 14th (fig. 55) the RIGG had winds over 50 kn and waves over 34 ft. OWS Lima measured 60-kn winds on the 14th, but did not venture out to see the waves. At this time another center had broken off and moved northeastward, and yet another center was moving across the southern periphery.

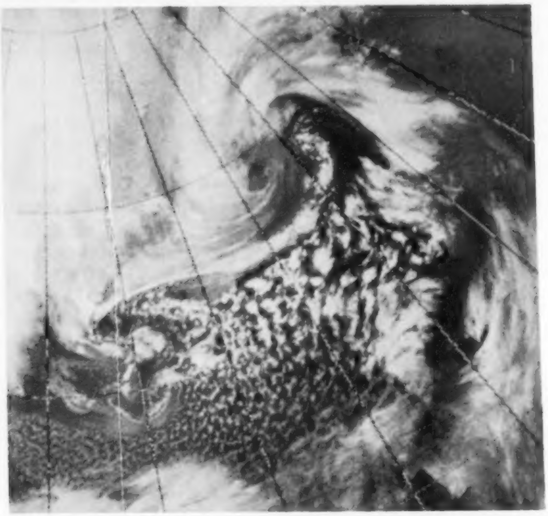

Figure 55.--The LOW is near Jan Mayen Island in the Greenland Sea. The cumulus clouds centered at 60°N show the instability. (DMSP Imagery)

This storm came out of the Midwest storm factory and took the Great Circle track toward Iceland. This took the storm over the Great Lakes on the 17th and 18th. On the afternoon of the 17th gale warnings were posted for Lakes Michigan, Huron, and Ontario (fig. 56). Later in the evening storm warnings were issued for Lake Huron and parts of Lake Michigan. Gale warnings were expanded to include the remainder of the Lakes. Winds of over 35 kn produced high-water levels and 10-ft waves over eastern Lake Erie. On the morning of the 18th, storm warnings were placed over Lakes Huron and Erie. Flooding and erosion warnings were in effect for the New York shore of Lake Erie. As the storm approached the coast it brought 40-kn southerly winds to the Bay of Fundy on the 18th. On the 19th a ship found 60-kn winds near 44°N, 60°W, the LINDIN had 57-kn winds near 67°N, 25°W, and the C. P. VOYAGEUR (44°N, 39°W) had 46-kn southerly winds with 39-ft swells. On the 20th OWS Charlie registered 28-

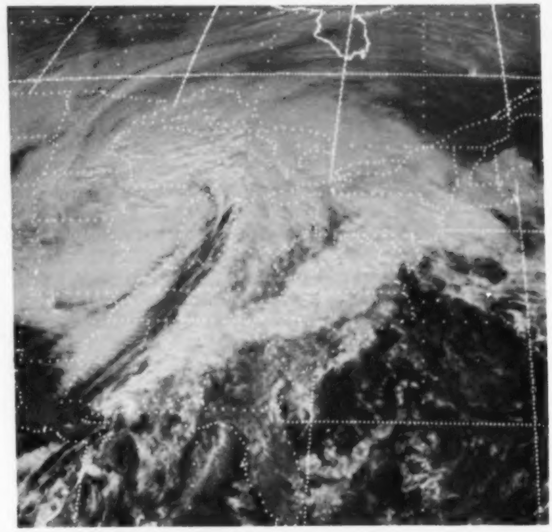

Figure 56.--This storm is centered over southern Lake Michigan at 1700 on November 17. Note the temporary clearing behind the cold front.

ft seas, while Lima was fighting 21-ft seas with gales in the 40's.

The 972-mb LOW skirted the southern Icelandic coast on the 21st. The SVENDBORG near 60°N, 20°W, was battling 60-kn winds from the west; while the IRAFOSS had only 44 kn, but the swell waves were 33 ft at her 60°N, 03°W, location. There were many 40- to 45-kn wind reports in the vicinity of 60°N and the Greenwich meridian. The highest waves were 21 ft. On the 22d the CITY OF ST. ALBANS found 60-kn winds near 53°N, 05°W. The MATCO AVON and another British ship were battered by 30-ft seas near 60°N, 02°E. By the 23d the LOW was north of Nordkapp and heading toward Spitsbergen. Another LOW had formed southwest of Iceland keeping some gale winds over the major shipping lanes.

As a LOW over Ontario with a front paralleling the Appalachian Mountains moved eastward, another LOW formed east of Long Island on the 24th. On the 25th the LOW was 978 mb near 41°N, 56°W (fig. 57). The JUPITER (43°N, 43°W) in the southerly flow had 55-kn

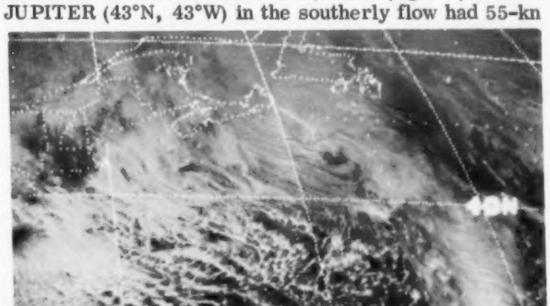

Figure 57.--This storm has an eye similar to a tropical storm, but that is the only similarity except it is cyclonic.

winds driving 20-ft seas and 26-ft swells. The BIRKENHAIN had 50-kn winds south of the center. The FRITHJOF (60°N, 49°W) north of the rapidly intensifying storm fought 60-kn easterly winds with 33-ft seas. At 1200 the storm was 966 mb near Belle Isle. A small LOW had developed south of Iceland. Except for it, this deep storm and a 1043-mb HIGH near 42°N, 20°W, were the only circulations over the ocean from 65°N to 20°N. Ocean Weather Station Charlie had 23-ft swells and Lima had 28-ft seas and swells.

The 970-mb LOW was moving northward over the Labrador Sea on the 27th. Except for the HIGH off of Portugal, its flow dominated the North Atlantic. The FRITHJOF was still near Kap Farvel at 59°N, 46°W, with 60-kn winds and 36-ft seas. Several other ships radioed winds over 50 kn and seas near 30 ft. As the LOW tracked toward the Davis Strait, another LOW formed east of Kap Farvel on the 28th. Two ships reported 55-kn winds in the 40°N latitudes along 25°W and the front. Another had 30-ft swells. On the 29th the Soviet ship ERET reported 78-kn westerly winds with 30-ft swells.

The LOW off Kap Farvel remained quasi-stationary until the 30th, when another deep system absorbed it. The original LOW continued northward to the vicinity of Thule, Greenland.

This storm settled over the Mediterranean Sea on the 26th as a frontal wave. The storm center remained nearly stationary near Rome, Italy, through the 29th, drifting slowly southward and eastward. During this time its circulation increased to cover most of western Europe and into the Sahara Desert. There were quite a few thunderstorms, and on the 28th Marseille measured 40-kn northerly winds (fig. 58). The BRITISH HOLLY off the southwest coast of Sardegna had 60-kn westerly winds and 41-ft swell waves. Another ship a few miles to the south had 33-ft waves. On the

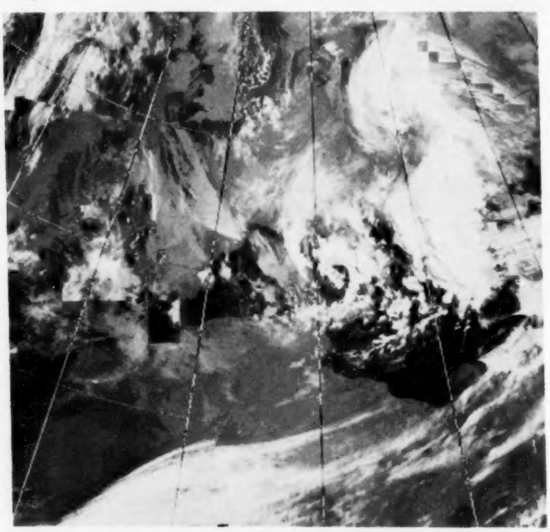

Figure 58.--The storm is centered south of Rome. The clouds over the Sahara show warm tropical air being fed into the circulation. The question-mark (?) shaped cloud over the Balkans is just that.

29th some of these high winds hit Naples with 40 kn. At the same time a Soviet ship reported 66-kn winds and 25-ft seas south of Menorca. The BRITISH HOLLY was now near Menorca with 39-ft waves. The BENCRUACHAN in the same vicinity had 48-kn winds and 30-ft seas. Winds up to 50 kn and high waves continued over the western sea into the 30th. At this time a LOW was moving eastward and weakening from its minimum of 985 mb at 0000 on the 29th. The winds slackened as the northwesterly circulation moved over the western sea. On December 1, the storm stalled over the Black Sea.

This incipient storm formed as a frontal wave on a weak warm front off Atlantic City, N.J., on the 28th. This should have been foreboding as it is not common for a frontal wave to generate on a warm front. The KHTB at 38°N, 65°W, found 40-kn gales as the storm moved south of Newfoundland on the 29th. By 1200 that day the storm was 978 mb near 49°N, 48°W. The ASIA FREIGHTER was south of St. Pierre with 55-kn winds and seas of code figure 30--49 ft.

At 1200 on the 30th, the storm had plunged to 956 mb near 55°N, 35°W. Several ships had winds over 60 kn. They included the AMERICAN ACCORD, ATLANTIC COGNAC, another French ship, and a Finish ship. The ACCORD plunged into 40-ft seas and the COGNAC had 33 ft. The 1500 report from OWS Charlie listed wave code 41--67 ft! Two later reports listed 39- and 41-ft waves. Wave reports over 30 ft continued into December 1. The winds were generally in the 40- to 50-kn range. The storm was moving northward on the 1st and died over Kap Farvel on the 2d.

This storm originated near Atlanta, Ga., late on the 29th. It raced up the East Coast and by December 1 was south of St. John's. It almost deteriorated to a trough, but by 0000 on the 2d it suddenly gained new

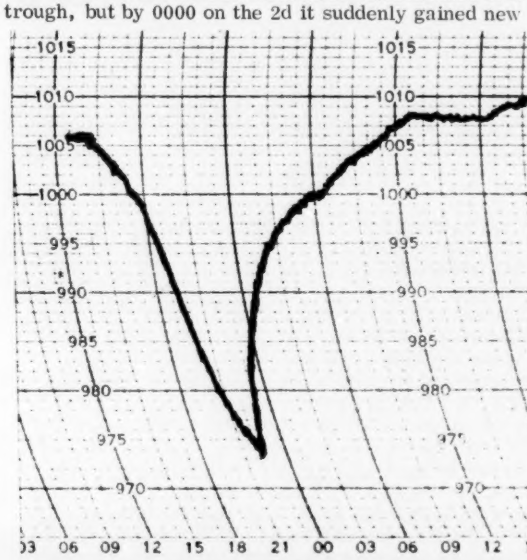

Figure 59.--The AMERICAN LEGACY passed very near the center of the 973-mb storm registering a minimum 973 mb.

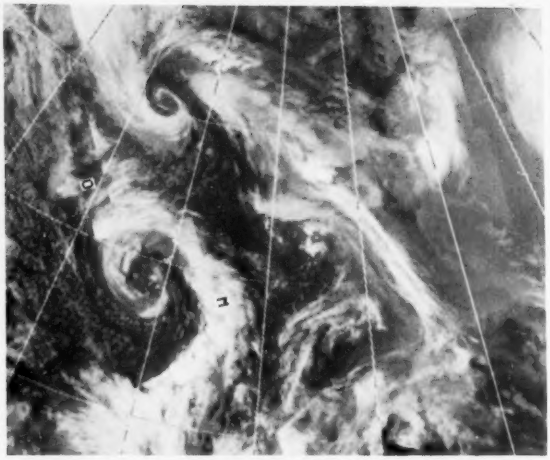

Figure 60.--The storm of interest is near 48°N, 22°W. Another LOW is nearly due north along 60°N, but it did not have the pressure gradient to produce severe conditions. (DMSP Imagery)

life. A French ship found 40-kn winds and 20-ft seas east of the front. The AMERICAN LEGACY was near 46°N, 34°W, with 45-kn gales and 15-ft seas. Her barograph (fig. 59) had dipped to 973 mb. At 0600 the storm's center passed almost directly over the HENRI POINCARE near 46°N, 26°W, with a pressure of 973 mb (fig. 60). Her weather report indicated 90-kn southwesterly winds, 29-ft seas, and 36-ft swells. Later at 2100 OWS Romeo measured 50-kn winds and 33-ft seas. Three hours later the seas were 36 ft. The storm was traveling northward off the coast of Ireland, bringing 40- to 50-kn winds on both sides of the United Kingdom. Late on the 4th it dissipated in response to another intense storm moving eastward.

Casualties -- The ferryboat AMERICAN LEGION (fig. 61) struck a concrete bulkhead during thick fog early on the 7th. The 21,000-ton vessel was going 10 kn at the time it struck the bulkhead. Some 240 passengers were injured. The 24,698-ton Greek bulkcarrier IRENE S. LEMOS and the 19,724-ton Panamanian bulkcarrier MARITIME JUSTICE collided in fog in the Mississippi River early on the 9th (fig. 62). The LEMOS sank and the JUSTICE went aground. The Greek freighter BLUE MED (5,218 tons) arrived Cartagena with severe weather damage.

The 852-ton French ISOLE was loading at Paspebiac, Quebec, and ordered to sail due to high winds. On departure the vessel was battered against the dock and sustained damage to the hull. During a heavy snowstorm on November 26, two barges were involved in heavy weather and grounded at East Chicago.

It was reported on the 30th that the Canadian icebreaker JOHN A. MACDONALD (6,186 tons) struck heavy ice between the 13th and 19th while operating near Booth Island. The forward starboard deep tank was flooded. The vessel will proceed to drydock for permanent repairs at ice breakup in 1979.

On the night of the 28th the 5,813-ton Brazilian cargo vessel LLOYDBRAS came in contact with the 12,808-ton Liberian bulkcarrier FEDDY at Genoa Roads during strong winds.

Figure 61. -- The American ferryboat AMERICAN LEGION found the concrete bulkhead to be more formidable than its bow. It must have been quite a jolt when the ferry struck the bulkhead in fog at 10 kn. Wide World Photo.

Figure 62.--The IRENE LEMOS (left) and the MARITIME JUSTICE (right) lie side by side in the Mississippi River showing their battered bows. Wide World Photo.

Rough Log, North Pacific Weather

October and November 1978

ROUGH LOG, OCTOBER 1978--The preferred mean storm path that primarily affected marine activity originated near Japan with an east-northeasterly path until the area of 45°N, 160°W, where it turned sharply northward to the south coast of Alaska. Another path came across northern Sakhalin Island and then into the Bering Sea. The Gulf of Alaska and Bristol Bay area was a mass of tracks as most storms moved into that area. Only two storm centers moved inland south of 60°N, one during the first week of the month and one the last week. Several storms wandered around the ocean north of Hawaii. These tracks compared favorably with climatology, except the northern path over the Sea of Okhotsk was farther north and more easterly oriented than normal. Also, a branch of the southern track that usually continues eastward toward the Queen Charlotte Islands was missing.

The mean pressure pattern reveals why the Queen Charlotte Island branch was absent. A 1023-mb Pacific High was centered near 41°N, 137°W, and ridged up the West Coast. This center is normally 1019 mb near 30°N, 140°W. The Aleutian Low was 997 mb over Bristol Bay, instead of 1001 mb north of Kodiak Island according to climatic records. There was an anomalous High over the East Siberian Sea.

The primary anomaly center was plus 8 mb off Vancouver Island; it was associated with the Pacific High. A minus 5-mb center was over southwestern Alaska. The largest anomaly center was plus 9 mb north of Wrangel Island and did not directly affect the weather experienced by most ships.

The upper air at 700 mb was nearly a carbon copy of climatology. The major exception was the Low over southwestern Alaska, which was deeper than usual and produced a pronounced ridging over northeastern Siberia.

In the eastern Pacific, hurricane Rosa and tropical storm Sergio completed the season. The central Pacific produced hurricane Susan, and the western Pacific was host to typhoons Nina, Ora, Phyllis, and Rita.

Extratropical Cyclones--Many thanks to the Port Meteorological Officer at Seattle, Don Olson, who sent the October radio log of Peggy Dyson (WBH-29). Many of these reports will be used in the following narratives. The first storm of the month was a continuation of typhoon Mamie. By 1200 on the 5th, it was a 984-mb LOW at 46°N, 178°E. The storm moved eastward with minimal gales until late on the 6th. At 1800 the NBMC radioed the first strong gale report of 44 kn in the sou-

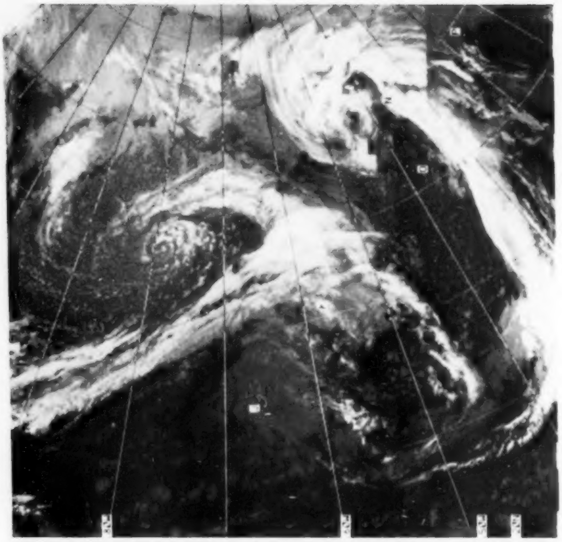

Figure 63.--This DMSP composite image for the 8th shows two storms--one over the Gulf of Alaska and the other south of the Aleutians. The square-type breaks and sharp variations in shade are where the various orbits were joined by a computer to form the composite.

thwest quadrant. There were several reports of 40 kn on the 7th. The PRESIDENT POLK (40°N, 154°W) sent one of them. Two Japanese ships had 25-ft waves. The NITTEN MARU (42°N, 154°W) reported 26-ft swell waves at 0600. At 1200 the storm was nearly centered over OWS Papa.

Early on the 8th the GLACIER BAY had 50-kn southeasterlies near 53°N, 147°W. The CHIKURA MARU (55°N, 140°W) was sailing into 26-ft swells. A ship far south along 42°N had 25-ft westerly swells. The BLACK HAWK (59°N, 147°W) and NEOGA at Kayak Island reported 50- to 60-kn winds with gusts to 80 kn. The BLACK HAWK had 30-ft southeasterly swells. The storm was now 962-mb near 54°N, 145°W (fig. 63). As it crossed Cook Inlet, it rapidly filled.

This storm matured from one of a series of frontal waves east of Tokyo on the 5th. The first high winds and waves came on the 7th. The NATALIE BOLTON (41°N, 155°E) found 44-kn northwesterlies. The KATENDRECHT north of the center had easterly 40-kn gales and 23-ft waves. The 980-mb storm was near the Near Islands at 0000 on the 8th with strong winds and high seas (fig. 63). The TOYOTA MARU No. 10 moved only one-tenth of a degree of longitude in 3 hr near 49°N, 170°E, as she contended with 60-kn winds and 30-ft waves. The PRESIDENT JEFFERSON was farther west with only 45-kn winds, but the swells were 28 ft. The KATENDRECHT was not doing any better with 55 kn and 26 ft. The WESER EXPRESS located the strong wind and wave band at 1800 on the 9th near 50°N, 158°W. At this time the LOW was moving along the Alaska Peninsula. On the 10th two SHIPs along 50°N between 150° and 160°W were hit by 28- to 33-ft waves. The storm moved ashore late on the 10th.

A LOW formed just north of Hokkaido on the 11th and moved northward. It suddenly turned southeastward on the 12th. On the 13th it caught at least five Soviet fishing vessels near 44°N, 150°E, with winds of 40 to 50 kn. At 1200 on the 14th the 980-mb center was close to 47°N, 157°E. The OHMINESAN MARU signaled 50-kn winds and 16-ft seas, while the PROFESSOR was instructed by 47-kn winds and 26-ft seas. Early on the 15th the WESER EXPRESS was sailing toward Japan with 60-kn winds and 39-ft swells pounding her starboard side near 40°N, 160°E. Three-hundred miles to the south a ship had 23-ft waves and 28-ft swells. At 0600 the WESER EXPRESS had sailed less than 50 mi in the past 6 hr, probably due to 46-ft swells. Other ships radioed reports of 25- to 30-ft waves.

Figure 64.--The center of this storm cannot be exactly determined by the cold (white) high clouds, and they obscure the warmer low-level (grey) clouds. The stairstep breaks are again the result of making a composite from orbits for various times and satellites (DMSP Imagery)

The high winds and particularly high swell waves continued into the 16th (fig. 64). The GOLDENROD at 41°N, 172°E, about 350 mi southwest of the LOW, had 51-ft swells on her report. Another ship near 37°N,

180°, reported 41-ft swells. Several others had 25- to 30-ft seas or swells. On the 16th the storm swung northward, and on the 17th it was absorbed by a LOW that had preceded it.

This extratropical storm was born out of tropical storm Ora on the 15th. It brought heavy rain to Japan as it moved south of the Islands. On the 16th 20-ft swell waves were found east of the storm along the warm front. On the 17th a SHIP reported 45-kn gales and 16-ft seas behind the cold front. The SURUGA MARU had 55-kn winds and 26-ft waves west of the center and south of a small LOW that was trailing this one and reinforcing the gradient.

On the 18th the 988-mb center was near 40°N, 170°E, at 0000. The FRIENDSHIP was north of the storm at 42°N, 167°E, with 40-kn easterly winds, 25-ft seas, and 30-ft swells. As the storm approached the dateline on Wednesday, a ship on the Tuesday side had 40-kn easterly gales and 26-ft seas. The storm crossed the dateline on the 19th, and the FRIENDSHIP and SANKO-SUN had 40- and 45-kn winds and waves to 27 ft while west and north of the storm, respectively. Later in the day a SHIP at 37.5°N, 178°E, fought 45-kn westerlies, 25-ft seas, and 36-ft swells.

As the storm moved northward into the Gulf of Alaska, it weakened with only minimal gales and less than 20-ft waves.

Monster of the Month -- This weak storm gradually worked its way from the eastern U.S.S.R. across the Kamchatka Peninsula into the open water on the 21st. It was meant for greater things when it was reinforced and strengthened by extyphoon Phyllis. On the 22d the 986-mb LOW was near 56°N, 178°E. There was a wave on the associated front near 44°N, 168°E, and Phyllis was near 39°N, 168°E. Several ships east of the front reported 40-kn gales with waves about 15 ft. A 1031-mb HIGH was blocking eastward movement, and the gradient was tighter on that side. The frontal wave and Phyllis joined on the 22d and raced northward up the front, greatly strengthening the LOW out of the U.S.S.R. The TAUBE (36°N, 165°E) was east of Phyllis at 0600 with 50-kn winds and 20-ft seas. The 198-ton crab processor MOKUHANA was damaged by the 3,847-ton ROYAL VENTURE in Dutch Harbor during this severe weather. On the 23d everything hit the fan. The eastern edge with southerly winds had reached Bristol Bay. Ships all over the area from the Bering Sea south to 35°N and 160°W to 160°E had high winds and waves. Among others the GOLDEN DAISY had 58-kn winds, the

Figure 65.--At about 2300 on the 22d, the primary LOW is relatively cloud free near 57°N, 180°. A secondary cyclonic circulation has formed near 46°N, 180°. (DMSP Imagery)

NEPTUNE DIAMOND had 48-kn winds with 25-ft waves, while a German ship encountered 30-ft swells. Later in the day the MAMMOTH FIR and PHILADELPHIA had 40- to 45-kn winds and seas to 33 ft (fig. 65).

Among the Aleutians the fleet really caught it. WBH-29 had 28 radio reports on the 23d. Many ships reported southeasterly winds of 60 to 80 kn with five of them reporting gusts to 100 kn. The lowest barometer reading by the YUKON off Dutch Harbor was 965 mb (28.50). The TARPIN near 54.7°N, 163.2°W, reported 30- to 40-ft swells. The KEY WEST near 56.1°N, 163.1°W, reported 50- to 60-kn southeasterlies gusting to 70 kn with 25-ft southerly swells. The vessel declared a Mayday and sank. At 0000 on the 24th, the large 958-mb storm was near 59°N, 166°W. At this time it turned southward, then eastward, moved over the Gulf of Alaska, and later down the Alaska panhandle. The GLADIOLUS (45°N, 175°E) had 60-kn west-northwesterly winds and 20-ft waves. The NORTH STAR III (54°N, 164°W) had 45 kn and 23-ft seas. The winds and waves had quieted some, but the EXPRESS and PACIFIC MARINER in the vicinity of Amak Island reported southwesterly 60-kn winds and gusts to 95 kn. The waves were still generally 25 to 30 ft, but the BULL DOG off Akutan called the swells 35 to 40 ft from the southwest. The ALEUTIAN PROVIDER (56.7°N , 147°W) said the swells were 30 ft from the south-southwest. On the 25th three previously named ships around 53°N, 167°W, had waves of 30 ft or more. After the LOW crossed the Alaska Peninsula the pressure rose rapidly, and the storm caused little trouble. It slowly moved southeastward paralleling the

coast and moved inland over Vancouver Island late on the 28th.

This minor LOW formed in the trough of another LOW that died over Siberia. On the 28th the 984-mb storm was near 57°N, 176°W, over the Bering Sea. A SHIP near 52°N, 176°W, had 56-kn winds on the 995-mb isobar. The EEKLO, HONGKONG PHOENIX, and GLADIOLUS all had 45- to 52-kn winds. Later, another SHIP had 30-ft seas. At this same time a frontal wave was racing eastward from over Honshu at over 60 kn. By 1200 on the 28th this LOW was at 46°N, 170°E. A ship that appeared to be the MAMMOTH FIR was south of the cold front at 42°N, 163°E, with 38-ft seas. The PRESIDENT PIERCE at 54°N, 178°W, was sailing into 30-ft seas and swells. By 1200 on the 29th this LOW

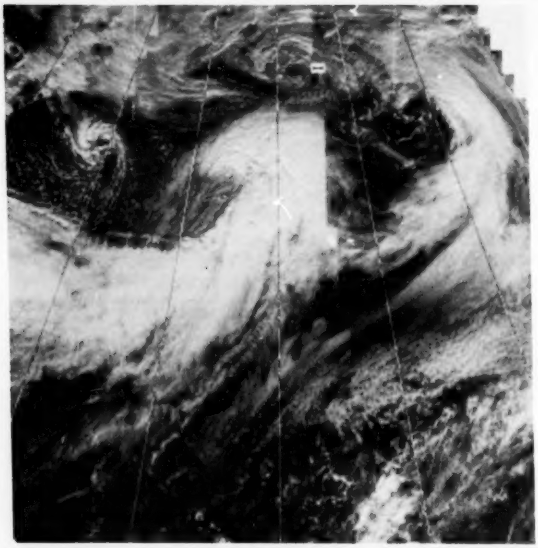

Figure 66.--The satellite passed over this area within a few hours of 0000 on the 29th. Two other cyclonic circulations (54°N, 170°E, and 57°N, 152°W) in addition to the primary one over the Bering Sea are indicated. (DMSP Imagery)

had raced to near Bethel, Alaska (fig. 66), and was the only circulation center at 954 mb. The ELBE EXPRESS found 60-kn southeasterly winds and 30-ft swells, while the FLORIDA MARU (55°N, 170°W) not far away 6 hr later had 55-kn winds from the west with 30-ft seas and 39-ft swells. Ships reporting to station WBH-29 Kodiak were calling winds up to 70 kn with gusts to 90 kn. The ALEUTIAN DEVELOPER reported 35-ft swells. On the 30th winds continued in the 50- to 60-kn range southwest of the center with the waves up to 38 ft. The Coast Guard was conducting a communication search for the GOLDEN VIKING.

On the last day of the month the VAN ENTERPRISE (48°N, 166°W) was on the southern edge of the cyclonic circulation with 50-kn winds and 20-ft seas. Five ships between 50° and 55°N and 135° to 160°W had waves of 25 to 30 ft. A SHIP near 52°N, 135°W, east of the front, reported 41-ft waves. On November 1 the storm turned eastward in response to a frontal wave that moved around the southern and eastern periphery. An English ship was treated to 58-kn winds with the frontal wave. An American ship at 54°N, 138°W, fought 55-kn winds and another nearby had 21-ft swells on the 2d. The EXXON SAN FRANCISCO had 26-ft swells slapping her beam. The frontal wave became the primary storm and moved across the mountains.

Tropical Cyclones, Eastern Pacific--Hurricane Rosa developed on the 2d about 300 mi south of Manzanillo. Moving northwestward, Rosa became a full-blown hurricane in just 2 days. By the 4th winds near her center were 65 kn; by the 5th they were 75 kn. However, as Rosa approached the tip of Baja California, the peninsula robbed her of her power (fig. 67). By the 7th she was just another helpless depression that had succumbed to the Baja.

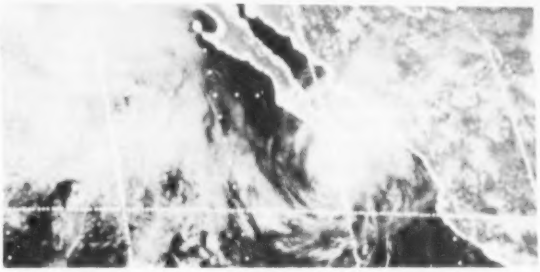

Figure 67.--Hurricane Rosa approaches Cabo Falso near noon on the 5th.

Sergio, the second Italian tropical cyclone of the month, very nearly followed in Rosa's footsteps. He was discovered on the 18th near 16°N, 107°W. Sergio moved northwestward as a tropical storm for 2 days. His maximum winds only reached 35 kn. Upper air conditions were unfavorable, and Sergio petered out on the 20th just after crossing the 20th parallel.

About the time Sergio was off the Mexican coast, hurricane Susan was throwing a scare at the Hawaiian Islands. Susan popped up along the 10th parallel near 145°W on the 18th. She headed west-northwestward as she developed. By late on the 19th she was a hurricane, but she was still a good distance from the Islands. Winds climbed as Susan's movement persisted (fig. 68). By the 21st it was apparent that the

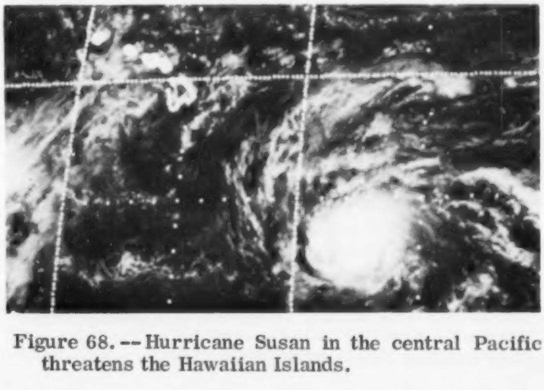

Figure 68.--Hurricane Susan in the central Pacific threatens the Hawaiian Islands.

big storm was a real threat. A hurricane watch was put into effect for the big island of Hawaii, and a 20-ft surf was probable even with the system some 450 mi southeast of Hilo. Winds were estimated at about 110 kn near the center. This was the most intense hurricane to threaten the Islands. Early on Sunday morning (the 22d) it was thought that Susan would pass within 20 mi of Hawaii. However, there was a dramatic change during the day, and Susan began to weaken. Her central pressure, which had fallen to 930 mb late Saturday night, had risen to 981 mb by late Sunday afternoon. Then in addition Susan began to turn toward the west-southwest and continued to weaken rapidly. The only ship encounter was the FNRZ, which ran into 50-kn northeasterlies on the 23d more than 400 mi to the northeast of the storm's center.

Tropical Cyclones, Western Pacific--Typhoons Nina and Ora developed in the Philippine Sea within 2 days of each other. Nina traveled westward across the Philippines (around 15°N), while Ora headed west-northwestward. On the 9th the MAYAGUEZ rescued 15 crewmembers from the sinking LOONG HSIANG No. 11, a 114-ton Taiwanese fishing boat, near 20.9°N, 120°E. The winds were northeast at force 7 with very rough northeasterly seas and swells on the northern edge of Nina (see "Letters to the Editor"). Nina was across the Philippines by the 10th as Ora was coming to life. The rugged terrain slowed her development, but not much. Early on the 10th ships were reporting winds in the 45- to 55-kn category in 15- to 20-ft seas. The NIKKO MARU, the GUPK, and the JTCF were all having a rough time. Then the ZCKN, sailing eastward to the north of the storm's center, was buffeted by 80- to 85-kn winds out of the northeast quadrant for about 18 hr until early on the 11th. She then ran into

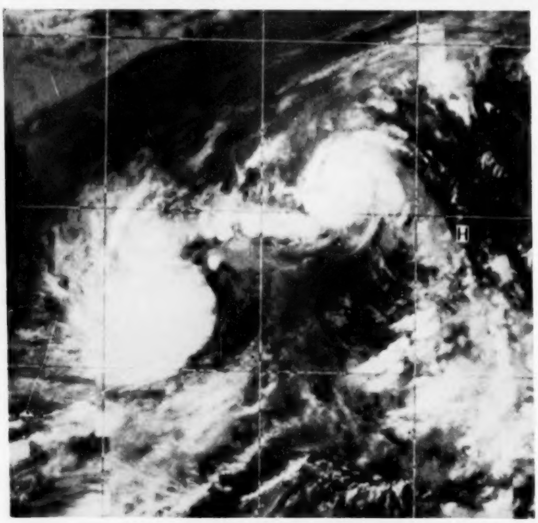

Figure 69.--The Mercator projection of the tropical ocean shows typhoons Nina and Ora. The connection between the two tropical cyclones indicates that the "Fujiwhara Effect" may have been involved. This is where two cyclone centers also rotate about some point between them. (DMSP Imagery)

70-kn winds again after a brief respite. Ora was not originally classified as a typhoon, but the ship encounters indicate she was a potent storm. While Ora was roaming the South China Sea, Nina was reaching typhoon strength among the southern Ryukyu Islands on the 12th (fig. 69). The combination of these two systems created dangerous conditions in the Formosa Strait. Winds of 50 to 60 kn whipped into 25- to 35-ft heights. This can be attested to by the GUPK, the GYNO, and the LOIRE LLOYD on the 12th and 13th. Ora's winds climbed to 80 kn near her center on the 13th. The following day she recurved toward the northeast and weakened. On the 15th she moved back out into the Pacific, just south of Kyushu, as a weakening tropical storm.

Meanwhile, Nina was recurving herself. She passed 60 mi to the west of Hainan on the 15th. She finally fizzled out just south of Hong Kong on the 17th after dumping 15 in of rain over the port in 2 days.

While Nina and Ora were dissipating, typhoons Phyllis and Rita were coming to life far to the east. Phyllis popped up about 300 mi southwest of Wake Island on the 15th. Two days later Rita made her debut some 600 mi east of Kwajalein. Phyllis moved west-northwestward than northward and by the 18th (fig. 70) was a typhoon hugging the 155th meridian. Meanwhile, Rita churned on a westerly course. As a typhoon she crossed Eniwetok on the 20th and had moved 60 mi to the south of Guam by the 23d. By this time Rita was a giant (fig. 71). Maximum winds near her center

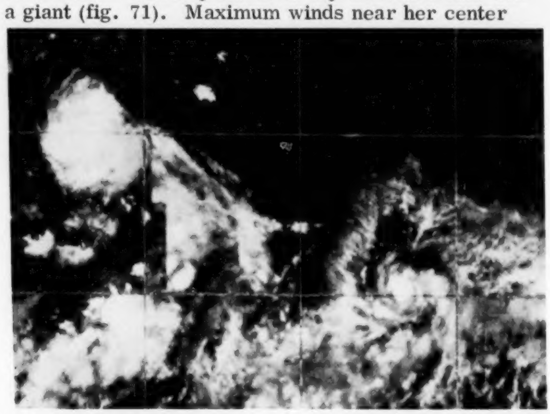

Figure 70. -- Typhoon Phyllis (left) is moving northward on the 18th, while Rita (right) is tracking westward. (DMSP Imagery)

climbed to 145 kn with gusts to 175 kn. Winds of 100 kn reached out to 25 mi, while gales extended 150 to 185 mi from her center. Guam suffered $2 million damage, and two American servicemen lost their lives. Phyllis by this time had recurved northeastward, dropped to tropical-storm intensity, and was turning extratropical as she crossed 40°N near 170°E. Rita's maximum winds remained in the 135- to 145-kn range as she approached the Philippines on a west-northwesterly track.

On the 26th Rita brought her deadly act across Luzon. The battering winds, torrential rains, and towering seas wreaked havoc throughout the central Philippines. More than 200 people lost their lives,

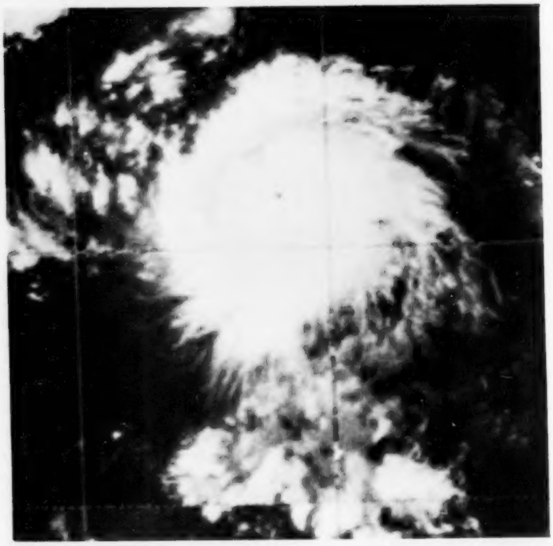

Figure 71.--Typhoon Rita is a giant storm on the 23d as she passed south of Guam and reached supertyphoon strength. (DMSP Imagery)

and another 354 were reported missing. As Rita cut across rice-rich central Luzon, she mowed down more than 50,000 homes and displaced almost 1-1/2 million people. Crop and property damage were estimated at $100 million. As seen from the air, the towns of Dingalan, Gabaldon, and Sicat were totally devastated. Rita was the worst typhoon to hit the Philippines in 8 yr.

Although the rugged terrain took its toll, Rita was still a typhoon upon emerging into the South China Sea on the 27th. She remained so until the 29th. During this period several ships encountered 45- to 52-kn winds in heavy swells and seas. The NEDLLOYD MARNE battled 30-ft swells, while the STRAAT NAGOYA was bounced around on 24-ft seas. The NEDLLOYD DEJIMA ran into 52-kn northeasterlies a good distance east of the center. Rita dropped to tropical-storm strength as she was heading southwestward. She reached the Vietnam coast near 13°N as a depression late in the day.

Casualties--Six crewmembers of the 965-ton Japanese chemical tanker KAIFUKU MARU No. 18 were rescued after the ship capsized southwest of Manila on the 12th. The rescue ship was the tuna boat RYOYU MARU No. 8. Seven crewmembers were missing. The deck barge TEKKO MARU No. 1 with 400 empty 20-ft containers in tow by the tug EAST SEA broke loose and drifted into the WESTERN OFFSHORE No. VIII off the west coast of Taiwan.

The 58,213-ton Liberian bulkcarrier CHU FUJINO suffered severe weather damage. The Norwegian vessel MARIE BAKKE struck a railroad bridge over the Willamette River in fog on the 28th on her maiden voyage. Both bridge and ship were damaged.

ROUGH LOG, NOVEMBER 1978--The cyclones that traversed the North Pacific this month were fewer than usual, but as is likely, they were large and deep. There are normally three primary tracks: Sakhalin Island into the south-central Bering Sea; east of Tokyo northeastward toward Bristol Bay; and midocean near 45°N into the Gulf of Alaska, with part splitting eastward to Vancouver Island. This month there were two primary "eyeball" average paths. One came from near Tokyo east-northeastward, then turned sharply northward between 170°E and 180° into the Bering Strait. The second path was from midocean into the eastern Gulf of Alaska.

There were some large differences in the monthly mean sea-level pressure chart and climatology. Climatology indicates three Low centers of 1001 to 1002 mb stretched across 53°N from the central Gulf of Alaska to north of Adak Island. This month there was one 995-mb center near 55°N, 170°E. The Pacific High was broken into two centers, rather than one elongated east-west ridge. The usual 1020-mb center at 30°N, 140°W, was replaced by a 1026-mb center near 36°N, 138°W. The other center was actually two 1019-mb centers along 29°N at 176°W and 172°E. These conditions set up two large anomaly centers--a minus 8 mb near 56°N, 170°E, and a plus 12 mb near 50°N, 140°W. These centers indicated that approximately north of 30°N and west of 180° the sea-level pressure was lower than normal, and east of 180° the sea-level pressure was higher than normal.

In the upper air at 700 mb a closed-Low center was located over the upper Kamchatka Peninsula instead of the normal trough. This produced a major long-wave trough along 170°E, which is usually over the coast of Asia. There were short-wave troughs over the Asian coast and along 160°W. The usual ridge was present over the North American west coast.

The western ocean produced tropical storms Tess and Winnie and typhoon Viola.

Extratropical Cyclones--This storm formed east of the upper Kamchatka Peninsula on the 2d. This peninsula often influences storms much like southern Greenland and Kap Farvel influence storms in the Atlantic. Old storms will move over the Sea of Okhotsk and degenerate with a new LOW forming east of the peninsula. This is what happened in this case.

A large HIGH was over the central ocean, and the gradient was tighter east of the front than to the west of it. On the 3d and 4th several ships found 40-kn gales and seas to 20 ft. On the 0000 chart of the 4th, Saint Paul Island recorded 50-kn winds. As the storm was passing through the Bering Strait, a frontal wave was rushing northeastward south of the Aleutians (fig. 72). The PORTLAND had 40-kn winds and 16-ft seas over the Gulf of Alaska. On the 5th the USCGC NORTHWIND had 40-kn winds and 21-ft seas within a few miles of OWS Papa, who measured 43 kn and 16 ft. South of Valdez the EXXON NEW ORLEANS found 55-kn winds and 30-ft waves. On the 6th the ARCO FAIRBANKS had 50-kn winds near Middleton Island. The original LOW had now dissipated, and the frontal wave became the primary LOW. It stalled on the coast and also dissipated.

A front stretched southwestward between two large HIGHs from Seattle to Hawaii. On the 4th a wave formed north of the Islands. The MARITIME RELIANCE (34°N, 154°W) was west of the front and well north of

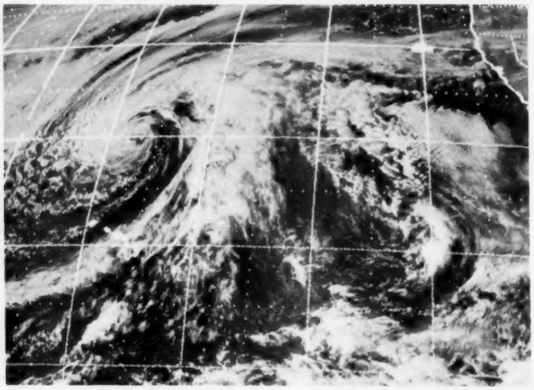

Figure 72.--The frontal wave is buried beneath the heavy cloud cover south of the Aleutians. With some imagination there appears to be a circulation centered on 50°N, 160°W. Another wave is dissipating south of the Alaska coast. The cutoff LOW was centered at 30°N, 157°W, at the time of this image--2045 on November 4.

the LOW with 50-kn northeasterly winds, 26-ft seas, and 20-ft swells. The SEATRAIN BUNKER HILL was about 90 mi away with 25-ft swells. Other ships southeast and southwest of the center were reporting 20-ft waves. The EASTERN SAGA found 30-ft swell waves at 1200 in the same general area (fig. 72). The storm moved northwestward until the 6th, when it suddenly turned eastward and then meandered between 30° and 35°N straddling 155°W prior to turning northward on the 10th. There were occasional gale reports with waves up to 23 ft at times. On the 11th the OCEAN BRAVE near 41°N, 161°W, and north of the storm had 43-kn gales and 28-ft swells.

The storm continued a stairstep track to the northeast and produced only minimal gales and light seas as it crossed onto the Alaska Panhandle on the 15th.

This storm was a continuation of tropical storm Tess who became extratropical on the 7th. The storm passed very nearly over a SHIP near 41°N, 173°E, with 64-kn winds. At 0000 on the 8th the LOW was 972 mb near 48°N, 179°E. The CGC JARVIS was near 54°N, 166°W, and mauled by 87-kn southeasterly winds. The LEO, west of the center, took a similar pounding by 78-kn winds. A SHIP south of the center may have had it worse than the others with 55-kn winds and 34-ft waves. The central pressure continued to drop. As the storm crossed the Aleutians, an island station measured winds over 40 kn on the synoptic time. On the 9th the pressure was 956 mb (fig. 73). The storm now mainly occupied the Bering Sea, and most ships had probably already fled. On the 10th the storm moved over Siberia and collapsed.

A short-lived LOW moved across the Kurile Islands. This storm formed in the sharp trough south of the LOW on the 12th. One of the first observations was by the TOYOTA MARU No. 10 indicating 30-ft swells behind the front.

By 1200 on the 13th, the tremendous LOW was 962

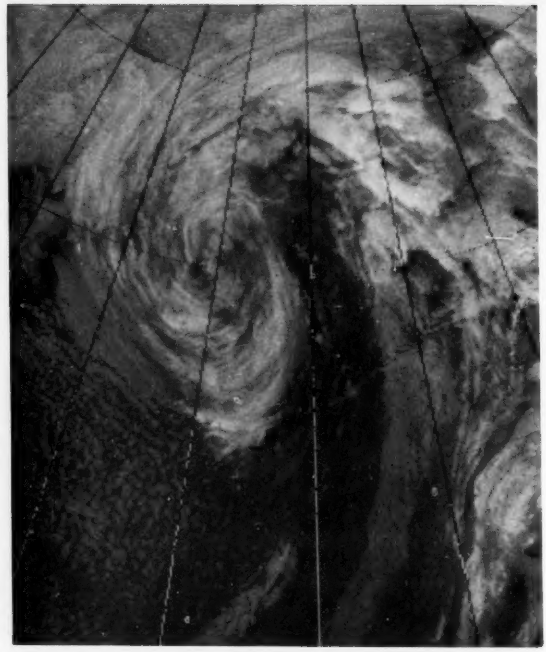

Figure 73.--The upper air LOW center was near 60°N, 180°, when this infrared image was sensed.

mb near 53°N, 170°E (fig. 74). The PRESIDENT MADISON, far south of the center near 35°N, 165°E, had 55-kn winds and 25-ft waves. There were several ships with 50- to 60-kn winds and high waves. The PESTOVO at 49°N, 179°E, had 36-ft waves. A Japanese ship 600 mi south of the LOW reported 68-kn hurricane-force

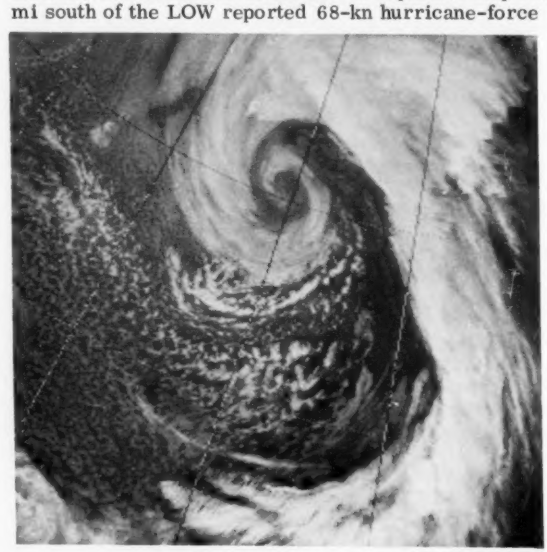

Figure 74.--The whirlpool effect of this large LOW is very clear as the cloud band spirals into the center.

winds. On the 14th the IRISH PINE, which was 450 mi south, had 30-ft swell waves. The storm passed to the west of the GLADIOLUS, but she was near enough to the 962-mb center to have a 982-mb pressure and 85-kn southeasterly winds. The KANESHIZU MARU (45°N, 165°E) was pounding into 28-ft waves on the 15th. The GLADIOLUS was headed into 58-kn winds. The storm had stalled on the 14th and disappeared on the 16th.

This storm formed in a broad flat gradient over the Sea of Japan on the 14th. The pressure gradient soon tightened and organized. By 1200 on the 16th the 980-mb storm was near 43°N, 163°E. The MAGELLAN MARU, 200 mi southeast of the center, had 28-ft swells from the south. On the 17th the winds were blowing in the 40-kn range. Many of the sea reports were near 20 ft. At 0900 the MAGELLAN MARU now near 41°N, 171°E, reported 43-ft swell waves. Three hours later they had dropped to 33 ft. On the 18th the ROKKOHSAN MARU was slightly south of Unimak Pass with 60-kn winds out of the southeast.

As the storm moved northward over the cold Bering Sea, the central pressure started rising. The storm weakened considerably with winds less than gale force.

Monster of the Month--This large storm had many Low centers during its lifetime. Some broke away from the main center, and others were frontal waves imbedded in the large overall cyclonic circulation. A LOW out of Manchuria moved across the Sea of Okhotsk on the 20th and stalled west of the Kamchatka Peninsula. On the 23d there was a double center straddling the peninsula, and another center forming to the south near 45°N, 160°E. By the 25th this southern LOW was the primary storm center alined with the primary upper air LOW. On the 24th the VAN CONQUEROR found the first 40-kn gales. At this time there were five centers in the overall circulation, which stretched from shore to shore. The CHEVRON ARIZONA was far to the southeast between one of those other centers and the Pacific High (33°N, 152°W) with 45-kn southerly winds. On the 25th the ZENLIN GLORY had 50-kn winds out of the west while west of that center. OWS Papa recorded 64-kn winds from the southeast.

The report from the VAN ENTERPRISE for 0000 on the 26th indicated 99-kn northerly winds near 49°N, 165°E. All the data in the report looked good and fit the analysis, but it appeared that the speed in knots had been doubled owing to the wind indicator showing meters per second. The closest ship with which to compare this speed showed 45 kn. The seas showed only 13 ft and the swells 20 ft. A Japanese ship south of one of the secondary LOWs had 55-kn winds, and the PRESIDENT MCKINLEY had 50 kn near 35°N and the dateline.

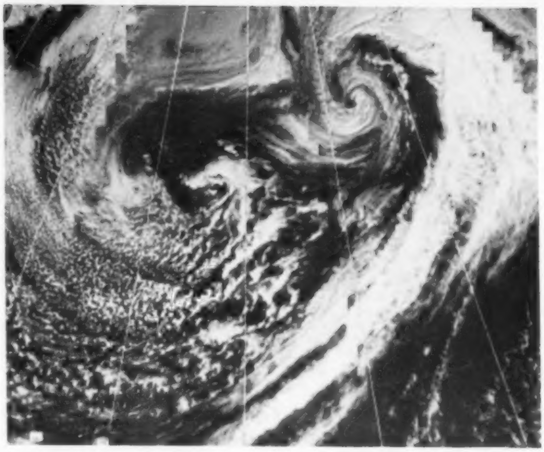

Figure 75.--The two consolidated centers are clearly outlined near 51°N, 157°W, and 45°N, 175°W.

On the 27th a SHIP near 37°N, 170°E, found 64-kn winds with 25-ft waves. The ARCO ANCHORAGE at 55°N, 140°W, was east of a secondary LOW with 45-kn winds and 30-ft waves. South of the primary LOW there were 40- to 50-kn winds plotted with waves up to 26 ft.

On the 26th the upper air LOW had split into two centers in the lower levels, and the original primary LOW with its upper air support was moving northeastward toward Nunivak Island. Another surface LOW remained with the other upper air center and began moving east-southeastward. There were four surface centers, but by the 27th they had combined into only two centers (fig. 75).

On the 28th the GREAT LAND and the PRINCE WILLIAM SOUND were south of Prince William Sound with 40-kn westerly winds and 36- and 25-ft waves, respectively. On the 29th the last one of the LOWs was moving toward the Queen Charlotte Islands.

On the 0000 chart of the 27th there was a large 1052-mb HIGH at 45°N, 110°E, over the Gobi Desert. A weaker 1023-mb HIGH was east of Hokkaido. An inverted trough formed between the two HIGHs as the eastern one moved southeastward. A LOW center formed near 31°N, 137°E, in this inverted trough. As the HIGH continued moving southeastward and the Gobi High remained stationary, the LOW moved northeastward and expanded.

On the 28th the TOYOTA MARU No. 11 and the VAN ENTERPRISE in the southeasterly circulation east of the center had 45- and 50-kn winds. The waves were running about 15 ft. The LOW was 989 mb near 44°N, 159°E, at 0000 on the 29th. The SANKOSUN was about 180 mi to the southeast with 45-kn southwesterly winds. The sea waves were reported as 41 ft, and the swell waves were also 41 ft from the south.

The LOW crossed into the Bering Sea near the Rat Islands at 0600 on the 29th. It was 972 mb at 0000 on

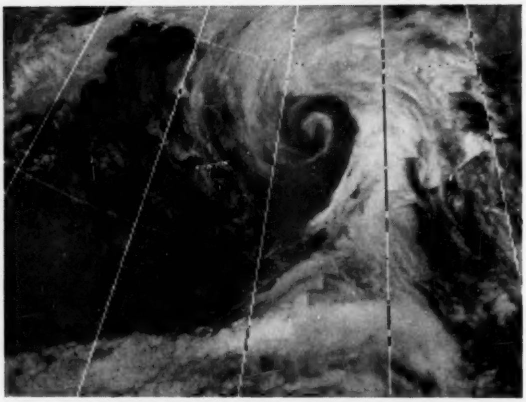

Figure 76.--The storm is centered over the central Bering Sea north of Adak Island.

the 30th (fig. 76). A SHIP north of Adak Island had 50-kn southwesterly winds and waves to 25 ft. On December 1 the pressure had dropped to 956 mb about 300 mi south of the Bering Strait. Two ships about 450 mi south of the center had winds between 40 and 50 kn. They were the ASIA ZEBRA with 30-ft waves and the PINE LIGHT with 39-ft swells. Saint Paul Island had 40-kn bone-chilling winds. On the 4th the storm disappeared north of the Strait.

Tropical Cyclones, Western Pacific--Tropical storm Tess formed west of Guam on the 1st. She moved toward the north-northeast and intensified. She was a tropical storm by the 3d, and by the 5th winds near her center were roaring at 60 kn as she crossed the 25th parallel near 149°E (fig. 77). Her strength was attested to by a ship which encountered 60-kn north-

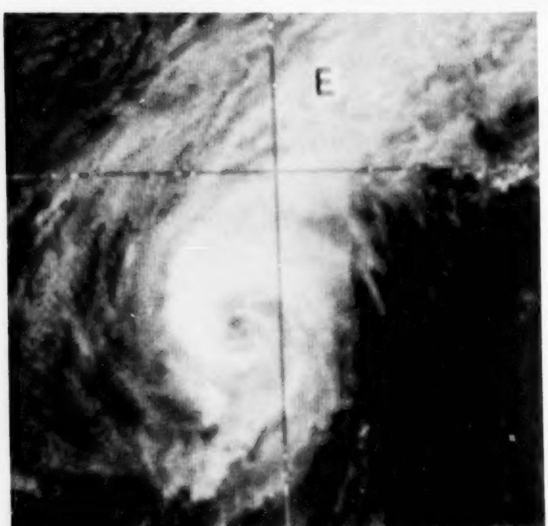

Figure 77.--Tess almost reached typhoon strength, but was not quite good enough. Gusts probably blew above the typhoon threshold.

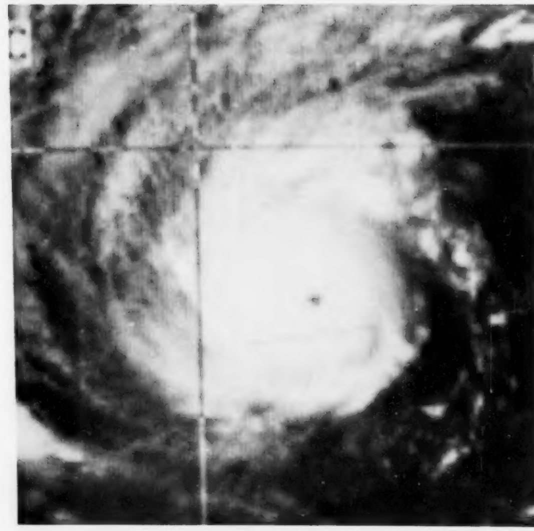

Figure 78.--Viola is blowing at 120 kn with a distinct eye. She is much better organized than was Tess.

erlies in 20-ft seas and swells at 0600. Moving to the northeast, Tess slowly began to turn extratropical with increasing latitude. However, she was still a potent storm. On the 7th several ships felt her fury. The ZIM GENOVA, some 200 mi to the southeast, reported 45-kn winds. The ZCLD about 100 mi to the south braved 30-ft swells in 62-kn winds, while the OVYZ far to the northeast reported 55-kn winds in 20-ft seas.

Typhoon Viola popped up just west of Truk on the 17th. She headed west-northwestward. It took her 3 days and 900 mi to reach typhoon strength, near 15°N, 135°E. By the 21st winds near Viola's center climbed to 120 kn (fig. 78). The SHINZUI MARU about 240 mi to the west-northwest was battling 43-kn winds amidst 17-ft swells. As Viola crossed the 20th parallel near 128°E, she began to recurve toward the northeast. At the same time her strength began to diminish. However, the ESSO CAMBRIA and the OKEAN both ran into 40-kn winds far to the west of the storm's center. By the 24th the east-northeastward-moving Viola was turning extratropical, but still generating gale-force winds. The MARCONA TRANSPORTER (28°N, 137°E) northeast of the storm was hit by 45-kn winds and giant 46-ft swells.

Three days later tropical storm Winnie sprang up to the southeast of Guam. She headed northward passing about 90 mi east of Saipan on the 28th. Winds reached 55 kn on the 29th, just after Winnie crossed the 20th parallel near 146°E (fig. 79). On the 30th the CHRYSANTEMA and the D5BU both encountered 40-kn plus winds in Winnie's wake as she sped rapidly east-northeastward to become extratropical.

A front from the last-described extratropical storm was being drawn into the circulation of Winnie on the 30th. By 0000 on December 1 she was extratropical at 38°N, 177°E. The storm had passed very near the SANKOSTAR at 1800 on the 30th. At 0000 on the 1st she reported 45-kn winds and 25-ft waves. The LOW was

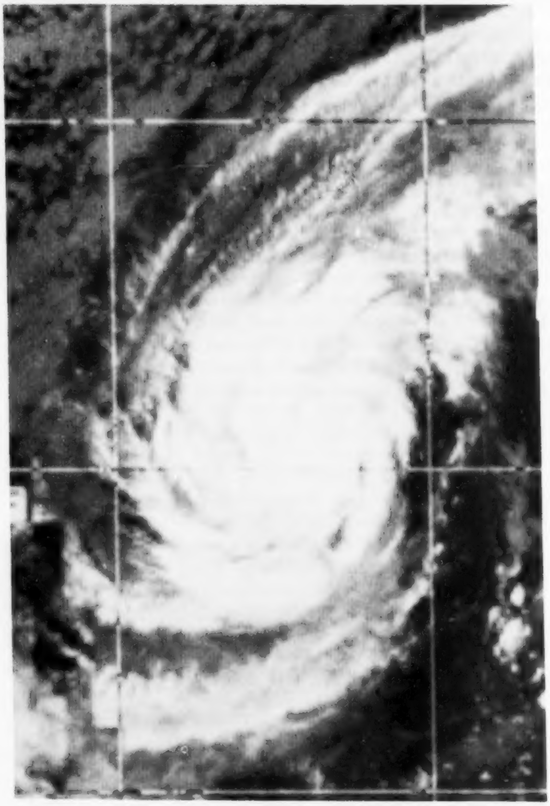

Figure 79.--Winnie also did not reach typhoon strength, but she made up for it in her extratropical stage.

972 mb near 49°N, 162°W, by 0000 on the 2d. A ship within 60 mi of the center had 52-kn winds and 26-ft seas and swells. Twelve hours later the central pressure was 960 mb east of Kodiak Island. There should have been many high-wind reports on the 2d, but none came over the radio. On the 3d the LOW crossed the coast and the PORTLAND (57°N, 146°W) was battered by 65-kn winds with 23-ft waves east of Kodiak Island. The GLACIER BAY, 4.5° longitude to the east, had only 45-kn winds, but she was hove to in 33-ft waves. Later at 1200 she had 50-kn winds with no waves reported as she sailed northwestward. By the 4th, the storm had collapsed over the interior.

Casualties--The 59,141-ton British GOTHIA TEAM contacted the lighter PUERTO ACEVEDO in Karachi anchorage in boisterous weather on the 8th.

The barge SEASPAN 191, the end barge in tandem with SEASPAN 190 and towed by SEASPAN WAVE, was found missing in heavy weather on the 18th. The barge was located stranded at Clark Island, Wash., on the 19th and refloated on the 21st.

The 26,681-ton Liberian bulkcarrier PACBARONESS radioed for help on the 21st after her cargo of lumber shifted in heavy weather near 50.3°N,166.3°E. The OCEAN BEAUTY responded and was standing by. Part of the PACBARONESS' deck cargo was lost overboard. The 3,000-ton Panamanian cargo ship NUSANTARA had a fire aboard while in Manila Bay, where she had sought shelter from typhoon Viola. Nine of the crewmen of the Panamanian freighter GIANT NAVIGATOR (4,009 tons) were missing after the crew of 25 jumped overboard on the 23d. The ship developed a list when its cargo of timber apparently shifted, and it was thought the ship would capsize in the rough seas churned up by typhoon Viola. A Japanese tanker rescued the other 16 crewmen. The 22,452-ton Indian JAGAT NETA requested survey of heavy-weather damage while at Kobe.

Marine Weather Diary

NORTH ATLANTIC, FEBRUARY

WEATHER. Usually the weather over the North Atlantic during February is a continuation of the storminess characteristic of January, and there are years when February weather is the most severe of winter. The average pressure distribution remains quite similar to that of January. The Icelandic Low fills to 1004 mb and is located near 60°N, 40°W. The central pressure of the Azores High drops to 1021 mb near 32°N, 22°W. This reduction in the average north-south pressure gradient is caused both by LOWs being less intense on the average during February, and by the more frequent appearance toward the advent of spring of a blocking HIGH at higher latitudes.

WINDS. Over most of the ocean north of 40°N, the prevailing winds are westerly. The winds over the Norwegian Sea are variable. North of 60°N, between Greenland and Norway, the winds vary about equally from westerly to southerly. West of the Bay of Biscay, the winds are variable. Between 25° and 40°N, the wind direction favors the southwest quadrant in the Atlantic. The direction along the Atlantic Coast of the United States is northwesterly to variable off Florida. Over the Gulf of Mexico it is northerly to southeasterly. Westerly to northwesterly winds dominate the Mediterranean Sea. Force 3 to 5 winds are the most common except off the coast of the Middle Atlantic States, where force 4 to 6 winds prevail. In the ocean bounded by approximately 45°N, 30°W, the Denmark Strait, and the Labrador Sea, force 5 to 7 prevail. The "northeast trades," 25°N to the Equator, blow 65 percent of the time with speeds of force 3 to 5.

GALES. Winds of force 8 or greater occur over 20 percent of the time in an area south of Iceland to south and east of Greenland to the Labrador Coast north of Belle Isle. Another area of gale-force winds is east of Newfoundland, centered about 48°N, 36°W, and 5° latitude in radius. Another area is over the Gulf of

Lions. The 10 percent occurrence line extends from about Cabo Finisterre to about 500 mi off Cape Hatteras where it turns northeastward to parallel the coast.

EXTRATROPICAL CYCLONES. This month LOWs form most frequently 150 to 250 mi off the East Coast, from Cape Hatteras northeastward to about the latitude of Cape Cod. This is part of a large area of cyclogenesis that extends from the Gulf Coast of the United States to the Bay of Fundy. Another major area of cyclone development and the path they follow is from the Grand Banks northeastward to Iceland. There also is a primary track northward from Newfoundland to southern Greenland, where it splits into the Labrador Sea and toward Iceland. Other tracks are over the northeastern ocean from west of Ireland toward the Barents Sea, from the English Channel across the Gulf of Finland, and from the Gulf of Lions southeastward across the Mediterranean Sea. The Gulf of Genoa is also a favorite area of cyclogenesis.

SEA HEIGHTS. Seas 12 ft or higher can be expected 10 percent of more of the time north of a line from a couple of hundred miles east of Cape Hatteras to Cape Finisterre, Spain. On the Mediterranean, 10-percent frequencies lie inside an ellipse stretching from Barcelona, Spain, to Crete and then northwestward to Sicily, Sardinia, and the Gulf of Genoa. Another small area of 10-percent frequency lies between Crete and Turkey. The coast of Colombia still hosts a 10-percent line off Barranquilla. An area of over 20 percent is located off the central coast of Norway. The highest frequencies of greater than 30 percent are found over a triangular area between 57°N, 43°W; 45°N, 42°W; and 62°N, 13°W; and in the Denmark Strait.

VISIBILITY. The frequency of low visibility (less than 2 mi) reaches 10 percent or more from Halifax, Nova Scotia, northeastward to a point near 50°N, 40°W, and then northwestward to near Cape Mercy. It also reaches 10 percent on the southeastern North Sea and over the waters around the Faeroe Islands and eastern Iceland. The frequency increases to more than 20 percent inside a coastal region from Cape St. John, Newfoundland, to Resolution Island and then southward to Ungava Bay, and over the Norwegian Sea north of about 72°N.

NORTH PACIFIC, FEBRUARY

WEATHER. February weather in general can be as rough as any month of the year over the middle and higher latitudes. The average central pressure of the Aleutian Low is 1000 mb and is near 51°N, 172°E. The subtropical Pacific High is 1020 mb and centered near 31°N, 138°W. A ridge of high pressure extends eastward from the central China coast. The 1033-mb Siberian High is centered over western Mongolia. The weather regimes are controlled by these three features.

WINDS. Westerly winds prevail over much of the ocean north of 30°N and west of 180°. Northerly winds dominate the East China Sea. Winds are variable over the central Aleutians, southeasterly over the western Aleutians, and easterly near the Pribilof Islands. From the Gulf of Alaska southward to near 40°N and east of 180°, winds are mostly southerly to southwesterly, although other directions are common during the frequent passage of LOWs. Over the extreme northern Gulf of Alaska, the prevailing winds are easterly, and northerly winds are very pronounced over the Bering Sea north of 60°N. The average speed of winds north of 30°N is force 4 to 6, although east of Honshu the wind blows at force 6 or 7, 41 percent of the time. The "northeast trades" extend northward to more than 20°N over most of the western and central ocean and to 30°N over eastern waters; south of 20°N, these winds are very steady. The wind speeds in the trades range from force 3 to 5. The "northeast monsoon" is steady over the South China Sea and the Philippine Sea south of 30°N and west of 150°E. Winds are quite variable over the eastern North Pacific between 30° and 40°N, southwesterly over the east-central ocean between 30° and 45°N, and variable over west-central waters between 25° and 30°N, and 135°E and 180°. Wind speeds over these areas usually average force 4. Northerly winds predominate over the Gulf of Tehuantepec, and in 71 percent of the observations they range between force 2 and 6.

GALES. The frequency of gales near and above 10 percent affects most noncoastal areas south of the Aleutians and north of a line from the waters southeast of Honshu to a point south of the Queen Charlotte Islands and west of Washington State. A maximum incidence of over 20 percent is found over a 200-mi-wide band 600 to 1,000 mi southeast of the southern tip of Kamchatka, an area east of northern Honshu near 37°N, 155°E, and south of the Gulf of Alaska near 52°N, 145°W. Gale-force northerly winds are encountered more than 10 percent of the time by vessels plying the Gulf of Tehuantepec off southern Mexico. These high winds occur when strong northers from the Gulf of Mexico funnel across the isthmus to the Pacific. In extreme cases, they may be felt more than 200 mi out at sea.

EXTRATROPICAL CYCLONES. The storms predominantly follow a northeasterly track. The principal areas of cyclogenesis are off Hokkaido, the East China Sea, about 600 mi south of Unimak Island, and about the same distance southwest of Vancouver Island. Secondary tracks converge 350 mi east-northeast of Hokkaido and head east-northeastward toward the Rat Islands in the western Aleutians. A primary track extends northeastward from the East China Sea to the waters south of the western Aleutians and then runs parallel to that island chain to the Gulf of Alaska. The passage of LOWs over the Gulf of Alaska along the track described above and the one entering from the southwest is more confined to the western portion of the Gulf. The storm path approaching Vancouver Island from the southwest does not contain a maximum concentration of individual cyclones until it reaches a point 600 mi from that island.

TROPICAL STORM activity is at the annual minimum during February. On the average, one can be expected every 4 yr over western waters. As in the other winter months, the principal region of cyclogenesis is east of the central and southern Philippines. Two out of every seven February tropical storms has reached typhoon intensity in the past.

SEA HEIGHTS. Seas of 12 ft or more are encountered from 10 to 20 percent of the time over most of the ocean area between latitudes 30° and 52°N from 140°W to 145°E. A small area with a similar frequency lies over the waters bounding Taiwan where the "northeast monsoon" blows strongly and steadily. Areas of 20- to 30-percent frequency extend between latitudes 44° and 49°N from 172°E to 153°E, and farther southeast 100 to 200 mi around a line drawn from 35°N, 165°E to 40°N, 175°W.

VISIBILITY. Areas of limited visibility (less than 2 mi) occur in more than 10 percent of the observations north of a line drawn from the Yellow Sea through the Sea of Japan, south of Hokkaido, and then east-northeastward to the Alaska Peninsula. A maximum frequency of over 30 percent surrounds the waters around Ostrov Paramushir, south-southwest of Kamchatka.

NORTH ATLANTIC, MARCH

WEATHER. March is a transition month. The weather retains many of the wintry aspects of January and February and at the same time begins to exhibit some features typical of spring. During the first part of March, the weather is generally a continuation of winter conditions, gradually approaching springlike characteristics near the close of the month. However, wide variations from the climatic averages may be expected, and this pattern is not always the rule. The Icelandic Low (1005 mb) rests southeast of Kap Farvel near 58°N, 40°W, while the Azores High contains two 1020-mb centers southwest of the Azores near 27.5°N, between 35° and 42°W.

WINDS from westerly quadrants generally prevail over the major part of the western North Atlantic north of 30°N. Northerly or northeasterly winds blow more often over the waters between southern Greenland and western Iceland than any other winds from the four cardinal and four intercardinal points of the compass. Winds shift to a southerly component as one moves eastward from 35°W and to variable in direction over the Norwegian Sea east of 5°W. Near the coasts of Morocco and Portugal, northerly winds predominate. South of 30°N, the "northeast trades" are the dominant winds over most of the ocean with few exceptions. East of the Florida coast to about 68°W, wind directions are southeasterly to southerly. There is a strong tendency for easterly and southeasterly winds over the Gulf of Mexico. Over the Mediterranean, westerly to northwesterly winds prevail. For the month as a whole, winds of force 4 to 6 prevail north of 40°N (north of 35°N, west of 40°W) and force 3 to 4 south of 40°N (south of 35°N, west of 40°W).

GALES (force 8 or higher) tend to decrease in strength and frequency during the latter half of March. On the average, gale-force winds have been noted in 10 percent of the ship observations north of a line extending roughly from Cape Hatteras to the Bay of Biscay, excluding the southern Norwegian Sea, the waters south of western Iceland down to 60°N, the seas west of southern Ireland to about 33°W, and the waters east of Newfoundland. A small area of gale frequencies greater than 10 percent covers the Gulf of Lions. The maximum frequency of gale occurrence, 20 percent, may be expected from the southern tip of Greenland south to about 55°N and between 40° and 50°W.

EXTRATROPICAL CYCLONES. Principal storm tracks head from the Great Lakes and the Carolina coast to Newfoundland. From Newfoundland, a primary track curves northward to the west coast of southern Greenland, and another track runs northeastward to Iceland and then into the Barents Sea. Over the Mediterranean area, a primary track extends from the Bay of Biscay east-southeastward to the southern Turkish coast.

TROPICAL CYCLONES. Only one tropical storm, a hurricane in the Lesser Antilles in 1908, has been reported in the North Atlantic in the past 104 yr.

SEA HEIGHTS of 12 ft or more are encountered more than 10 percent of the time north of a line from about 150 mi east of Cape Hatteras to Brest, France; in a small area northwest of Barranquilla, Colombia; in the Strait of Otranto between Italy and Albania; and from the coast of Sardinia northwestward to France. A large irregularly shaped area of 20-percent frequency lies in the open ocean bounded roughly by the following coordinates: 60°N, 55°W; 68°N, 25°W; 60°N, 10°W; 43°N, 43°W. Smaller areas of 20-percent frequency lie northeast of Bermuda, west of central Norway, and in the Gulf of Lions.

VISIBILITY less than 2 mi occurs 10 percent or more of the time over a 400-mi-wide elliptically shaped area extending northeast-southwest from 55°N, 40°W to 42°N, 58°W; over an area of the Labrador Sea from Cape Mercy to Cod Island; over the North Sea from southern Norway southeastward to Denmark and Sweden; and north of a line extending from southern Greenland to north of Iceland and then to the Barents Sea.

NORTH PACIFIC, MARCH

WEATHER. March is normally considered one of the transitional months between winter and spring over the North Pacific. Compared to the North Atlantic, weather improvement is somehwat delayed by the vast expanse of the ocean and the lingering winter climate over Siberia. Stormy weather is about as frequent as in the preceding month along the northern routes, especially from the western Aleutians southwestward to the vicinity of Japan. The 1005-mb Aleutian Low lies about 250 mi south of the Komandorskiye Islands and the Pacific High (1022 mb) rests near 33°N, 144°W.

WINDS. From about 40° to 60°N, winds from the westerly quarter are most frequent, although winds are variable north of the Aleutians and easterly over the Gulf of Alaska. In 40 to more than 60 percent of the observations, the wind force is 4 to 6. However, near the North American coast the most frequent wind speeds are force 4 to 5. West to north winds are most prevalent in Japanese waters south of 40°N where more than 50 percent of all winds vary between force 4 and 6. During March, the northeast monsoon continues to prevail along the Asiatic coast south of Shanghai and over Philippine waters. From 25° to 40°N, wind directions are variable, and the force is from 3 to 5 more than 50 percent of the time. The "northeast

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trades" are the dominant winds from 25°N to the Equator and extend northward to about 30°N over the eastern part of the ocean. The usual wind speeds, force 3 to 5, persist more than 60 percent of the time over the ocean area under the influence fo the trades. Northerly force 2 to 3 winds blow 40 percent of the time over the Mexican waters out from the Gulf of Tehuantepec.

GALES. In the central and western North Pacific, gales may be expected as far south as 30°N. In this area, north of 35°N and west of 175°W, 10 to more than 20 percent of ship reports contain winds of force 8 or higher. Over the eastern part of the ocean east of 175°W, there is a large reduction in gale frequencies compared to February, and occurrences are generally confined to latitudes north of 35°N. Percentage frequencies of gales in the central Gulf of Alaska, 10 to 20 percent in the preceding month, drop to 5 to 10 percent during March. Gales over the Gulf of Tehuantepec may be expected more than 5 percent but less than 10 percent of the time.

EXTRATROPICAL CYCLONES. The greatest frequency of cyclogenesis in the Northern Hemisphere takes place in the area off the Ryukyus in March. These storms run northeastward to an area about 250 mi east of Hokkaido where they join another primary track coming from La Perouse Strait between Sakhalin and Hokkaido. East of Hokkaido, the primary paths head northeastward to the western Aleutians where they either continue into the eastern Bering Sea or curve to the east-northeast and parallel the Aleutians and Alaska Peninsula until reaching the Gulf of Alaska. Another track extends from 50°N, 160°W, to the Gulf of Alaska. A storm track heads east-southeastward from the Gulf of Alaska to the Alaska Panhandle.

TROPICAL CYCLONES are infrequent during March. A tropical storm can be looked for once every 2 yr over the western ocean. Half of these tropical storms develop further into typhoons. Tropical cyclones during March usually sprout up east of the central and southern Philippines and west of 170°W.

SEA HEIGHTS of at least 12 ft occur more than 10 percent of the time in a somewhat rectangular area bounded approximately by 50° and 33°N, and 155°E and 140°W.

VISIBILITY. The southern limit of 10-percent frequency of low visibility (less than 2 mi) extends from Mys Alevina, Siberia, southward to 42°N, 160°E, and then northeastward to west of Kodiak Island. This frequency increases to more than 20 percent from the waters around the northern Kurils northeastward to the Komandorskiye Islands and then northwestward to Mys Ozernoy.